INTERMAGNET

Technical Reference Manual

Version 4.6 (2012)

Web Site: www.intermagnet.org

INTERMAGNET TECHNICAL REFERENCE MANUAL

Version 4.6
2012

Edited by: Benoît St-Louis

This document has been prepared by the INTERMAGNET Operations Committee and Executive Council. Every effort has been made to ensure that the information is accurate and current. The document is distributed in the hope that it will be a useful reference not only for those participating formally in INTERMAGNET, but also for the greater geomagnetic community.

Acknowledgements

We gratefully acknowledge the many and significant contributions and comments provided by our colleagues.

This manual is based on the original document (INTERMAGNET Technical Reference Manual version 1.0 1994)
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QUICK REFERENCES

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➤ **DVD/CD-ROM DISTRIBUTION OFFICE**

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CHAPTER 1 INTERMAGNET

1.1 INTRODUCTION

This manual describes the global near-real-time magnetic observatory network, known as INTERMAGNET. Throughout the document, the term "magnetic observatory" will mean a recording station where absolute measurements of the geomagnetic field are made on a regular basis over many years and which produces data of the requisite quality for secular variation studies. The term "near real-time" in this context means that data are supplied for distribution within 72 hours of acquisition.

The automation of magnetic observatories in several countries, operated remotely by means of telephone communications, has demonstrated that data on the dynamic magnetic field of the Earth can be collected quickly using modern data capture techniques and communications systems. It is logical to coordinate national activities and to extend the use of such techniques worldwide. It is now possible to adopt a new standard for geomagnetic measuring and monitoring equipment and to transfer data rapidly to regional Geomagnetic Information Nodes (GINs) using satellite and network communications. These geomagnetic information nodes collect data from their sector of the globe for dissemination to the user communities in a timely manner. GINs can, when needed, exchange data and may also disseminate products such as geomagnetic indices and activity models.

A successful pilot scheme operated during 1989, including the UK, USA, and Canada transmitting and receiving at 12 minute or 1 hour intervals geomagnetic data recorded every minute. As a result of the pilot scheme, the IAGA Executive Committee endorsed INTERMAGNET. The SEDI (Study of the Earth's Deep Interior) Steering Committee has also endorsed INTERMAGNET.

1.2 INTERMAGNET OBJECTIVE

The INTERMAGNET objective is to establish a global network of cooperating digital magnetic observatories, adopting modern standard specifications for measuring and recording equipment, in order to facilitate data exchange and the production of geomagnetic products in close to real time.

1.3 HISTORY AND STATUS OF INTERMAGNET

The possibility of worldwide data communication between magnetic observatories was first raised seriously at the Workshop on Magnetic Observatory Instruments, held in Ottawa, Canada, in August 1986. Further discussions, particularly between the British Geological Survey (BGS) and the US Geological Survey (USGS) took place in May 1987 at the Nordic Comparison Meeting held at Chambon la Forêt, France. A pilot scheme between BGS and USGS was described at the sessions of Division V of IAGA during the XIXth General Assembly of IUGG in Vancouver, Canada, in August 1987, with the proposal that the geomagnetic community should adopt automatic observatories with satellite communications as its mode of operation for the future. INTERMAGNET embodies the proposal to extend worldwide the network of observatories communicating in this way.

At present the observatories shown in Appendix B-1 are transmitting through satellites, or daily by computer link, to GINs. More stations are coming online rapidly.

GINs are now operating in Edinburgh (BGS), Golden (USGS), Kyoto (Kyoto U.), Ottawa (GSC), and Paris (IPGP).

1.4 THE INTERMAGNET PRINCIPLES AND CONDITIONS

INTERMAGNET is operated according to principles and conditions which are accepted as necessary and desirable for maintaining a service of rapid magnetic observatory data exchanges for the international scientific community and for commercial users.

1. INTERMAGNET is a non-exclusive program of worldwide data exchange between magnetic observatories.
2. An INTERMAGNET aim is the establishment and maintenance of observatories in remote areas where local support is lacking.
3. INTERMAGNET encourages the establishment and maintenance of digital observatories in developing countries, with the involvement and enhancement of local science and technology.
4. Each participating country/institution is expected to bear the costs of its participation in INTERMAGNET.

5. Data will be transmitted from observatories or operating institutes to regional geomagnetic information nodes (GINs) by satellites, computer networks or by other near real-time means, using standard INTERMAGNET formats.
6. Regional geomagnetic information nodes will exchange data and data products globally as rapidly as appropriate, and will maintain data files for all contributing observatories for a period commensurate with the immediate usefulness of the product.
7. The collected data will be made available to the scientific community and to participating observatories on media and in formats approved by the INTERMAGNET Executive Council.
8. All data are supplied on the condition that they are not used for commercial gain (media, transcription and other costs may be charged to the user).
9. The INTERMAGNET Executive Council recognizes the value to commerce of geomagnetic data and derived products which are available in near real time, and accepts the right of participating institutions to recover costs for services and to levy charges where possible and as necessary. Participating institutions will undertake to safeguard the interests of fellow participants, concerning the commercial usage of their data.
10. Each INTERMAGNET GIN will provide annually to each participating institution or observatory a statement of data received by the GIN and of its data supplied by the GIN to users.
11. Participating institutes will co-operate to facilitate the production of globally representative data products, such as the official IAGA indices.
12. Participating institutions will agree to submit definitive data annually for inclusion on an INTERMAGNET DVD and will receive in return one copy of the DVD free of charge.

1.5 PARTICIPATION

INTERMAGNET membership is available to institutions who wish to operate one or more INTERMAGNET Magnetic Observatories (IMOs). Members agree to allow distribution of their IMO data in accordance with INTERMAGNET guidelines. In return for participation, Institutional membership provides: access to near real-time data from any IMOs for all members of the Institution; access to the best in magnetic observatory technologies and assistance in implementing them and possibilities of discounts on satellite communications. There are, at present, no membership fees. An application to become a member is submitted to the INTERMAGNET office for approval by the Executive Council, subject to technical evaluation by the Operations Committee. The membership application form is included in Appendix G-1.

Individual researchers may also be granted access to IMO data distributed through GINs. They must apply to an INTERMAGNET GIN and agree to abide by all INTERMAGNET guidelines. They will then be put in contact with the most convenient GIN. Charges for access to data may apply.

1.6 PRODUCTS

Minute values of geomagnetic components along with other INTERMAGNET products may be retrieved from the web site (http://www.intermagnet.org) under Data. Minute values are kept on-line permanently to allow comparisons between preliminary and definitive data and to give data sets that can be used to test software that works with preliminary data. When available, definitive data should preferably be used. A DVD (CD-ROM before 2006) containing definitive data from INTERMAGNET observatories is created annually. The INTERMAGNET DVDs/CD-ROMs are available at no charge to participating institutes and to bona fide scientists for academic purposes only. Technical help for operators of IMOs may also be available by special arrangements through the INTERMAGNET office.

1.7 CONDITIONS OF USE

The Geomagnetic data available through INTERMAGNET are provided for your use (and for the use of colleagues collaborating on the same project) and are not for sale or distribution by you to third parties, without the express written permission of the Institute that operates the observatory. Any report or publication that makes use of these data should acknowledge that Institute as the source. One copy of each report or publication should be sent to the Institute.

We ask that the data not be used for commercial purposes, nor in any project in which you, your organization, or your collaborators are in a commercial agreement with any third party.

Your e-mail address, which you provide to INTERMAGNET when requesting data, will be given to the Institute supplying the data so that it may monitor the use of its data.

By accessing these data you signify your acceptance of these terms and conditions. For commercial applications of observatory data, please contact the operating Institute directly.

INTERMAGNET accepts no liability in respect of loss, damage, injury or other occurrence arising from the provision of these data.

1.8 INTERMAGNET MANAGEMENT

The Executive Council establishes policy for INTERMAGNET, deals with questions of international participation and data exchange, and communicates with national agencies and international scientific and funding agencies.

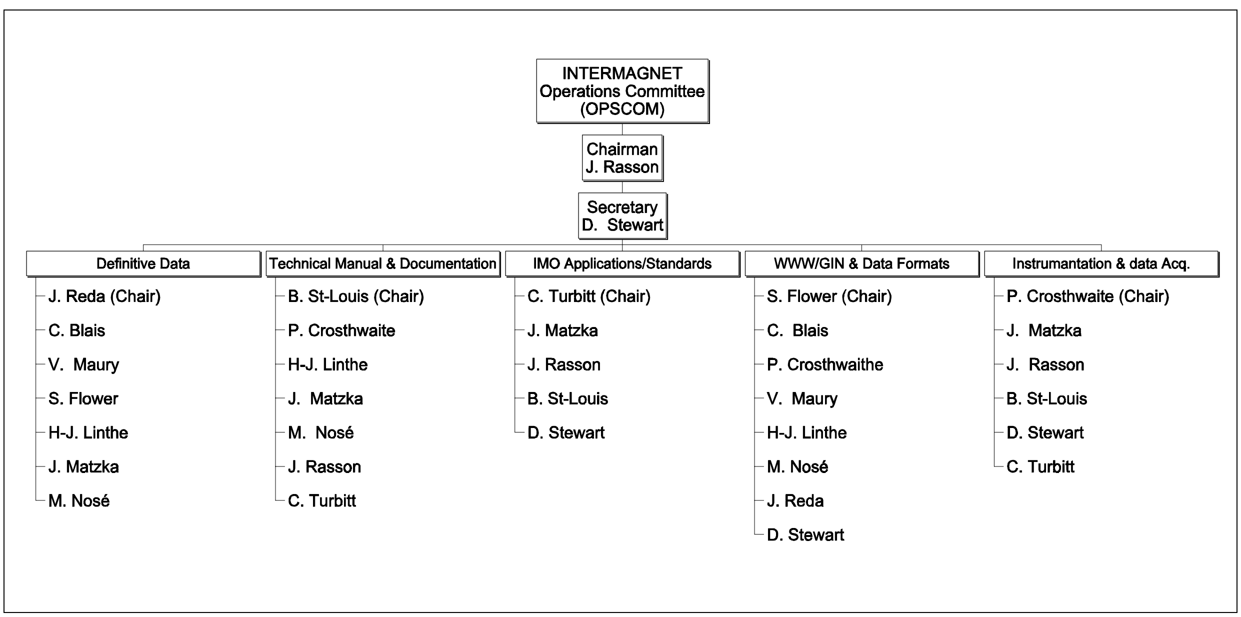
Executive Council membership:

J.J. Love	(USA) (Chairman)
D. Boteler	(Canada)
A. Chulliat	(France)
D.J. Kerridge	(UK)

The Operations Committee advises the Executive Council on matters relating to magnetic sensors, data capture and data processing, and on communications options, protocols, etc. The Operations Committee is also responsible for establishing and maintaining standards of operation and uniform data formats and transmission characteristics which optimize global exchange.

Operations Committee membership:

C. Blais	(Canada)
P. Crosthwaite	(Australia)
S.M. Flower	(United Kingdom)
H-J. Linthe	(Germany)
J. Matzka	(Denmark)
V. Maury	(France)
M. Nose	(Japan)
J. Rasson	(Belgium) (Chairman)
J. Reda	(Poland)
B.J. St-Louis	(Canada)
D.C. Stewart	(USA)
C.W. Turbitt	(United Kingdom)



CHAPTER 2 INTERMAGNET MAGNETIC OBSERVATORIES - IMOs

2.1 SPECIFICATIONS

An INTERMAGNET Magnetic Observatory (IMO) is a magnetic observatory, having full absolute control, that provides one minute magnetic field values measured by a vector magnetometer, and an optional scalar magnetometer, all with a resolution of 0.1 nT. Vector measurements performed by a magnetometer must include the best available baseline reference measurement.

An IMO must try to meet the following recommendations:

Definitive Data

Accuracy: ±5 nT

Absolute Measurements (See Section 2.6)

Vector Magnetometer

Resolution:	0.1 nT
Dynamic Range:	8000 nT High Latitude 6000 nT Mid/Equatorial Latitude
Band pass:	D.C. to 0.1 Hz
Sampling rate:	1 Hz
Thermal stability:	0.25 nT/°C
Long term stability:	5 nT/year

Scalar Magnetometer

Resolution:	0.1 nT
Accuracy:	1 nT
Sampling rate:	0.033 Hz (30 sec)

Clock Timekeeping

Observatory data logger:	5 seconds/month
Data collection platform:	± 1.5 sec GOES, GMS ± 1.0 sec METEOSAT

Recorder

An on-site recorder is necessary so data are not lost as a result of satellite transmission outages.

Transmission

Transmission must be by satellite or other electronic means, within 72 hours of acquisition, to a Geomagnetic Information Node (GIN).

Note: Keeping within the time slot for satellite transmission is an important duty of an IMO operator. When advised by a GIN of a time drift, the IMO operator must make the necessary corrections within 24 hours.

Other

Data format:	IAGA2002 or IMFV2.83 or IMFV1.23 (or later)
Definitive data:	to be submitted for inclusion on the DVD/CD-ROM
Baseline data:	each component to be submitted for inclusion on the DVD/CD-ROM
Filtering:	to INTERMAGNET standard (Section 2.2)

Proton Gyromagnetic Ratio

In 2009, INTERMAGNET adopted the new proton gyromagnetic ratio published by the CODATA group in 2006: $g_p = 2.675153362 {*} 10^8\ T^{-1}s^{-11}$

2.2 DATA SAMPLING AND FILTERING

In its Resolution 12 from the 1979 Assembly in Canberra, IAGA noted the desirability of digital magnetic observatories using a sampling rate no slower than once every 10 seconds. In that resolution, IAGA also stated that the one-minute means should be centered on the minute.

To minimize aliasing of higher frequency signals into the pass-band of the final minute data series, anti-aliasing filters should be included in the analogue portions of magnetometers before analogue-to-digital conversion. The filter responses should be matched to the chosen primary digital sampling rate. Subsequent to the digital sampling, INTERMAGNET requires that a numerical filter be applied in order to obtain the final minute data series.

One digital filter that is widely used by INTERMAGNET can be achieved by applying the following coefficients (for a Gaussian filter) to a series of 19 samples of 5-second data:

C0 = 0.00229315	C10 = 0.11972085
C1 = 0.00531440	C11 = 0.10321785
C2 = 0.01115655	C12 = 0.08061140
C3 = 0.02121585	C13 = 0.05702885
C4 = 0.03654680	C14 = 0.03654680
C5 = 0.05702885	C15 = 0.02121585
C6 = 0.08061140	C16 = 0.01115655
C7 = 0.10321785	C17 = 0.00531440
C8 = 0.11972085	C18 = 0.00229315
C9 = 0.12578865	

For a filter output value to be centered on the minute, coefficient C0 is applied 45 seconds before this minute and coefficient C18 is applied 45 seconds after the minute.

In addition to the attenuation provided by the numerical filter, a “natural filter” applies, estimated at -9 to -18 dB/Octave typically, caused by the decrease in energy of the natural field with increasing frequency.

Examples of other acceptable sets of filter coefficients, for use with various sampling rates of properly anti-aliased signals are presented in Appendix F-1.

A scalar magnetometer must provide a sample centered on the same time as the output of the digital filter used with the vector magnetometer.

When mean values are to be calculated the question of how to handle missing data arises. For a number of reasons it is difficult to devise a simple objective rule that can be applied to all cases. INTERMAGNET recommends a simple and pragmatic approach; mean values may be calculated when 90% or more of the values required for calculation of the mean are available. When fewer than 90% of the required values are available the mean value should be assigned the value used to flag missing data. INTERMAGNET recommends adoption of this rule for both simple mean and weighted mean calculations. For example, a simple hourly mean value may be computed when 54 or more one-minute values are available for the hour. Similarly, if a one-minute value is constructed from one-second samples, the one-minute value may be computed when 54 or more one-second samples are available. In this case the weights (filter coefficients) assigned to the samples must be re-normalized (the sum of the weights applied to the samples used to calculate the mean value must be unity). INTERMAGNET observatories are expected to provide high levels of data continuity, so this rule is expected to be applied only rarely.

2.3 DATA ENCODING FOR ELECTRONIC MAIL TRANSMISSION

Electronic mail transmission of data to a GIN must be done using IAGA 2002 Format or INTERMAGNET GIN Dissemination Format for Minute Values IMFV1.23 described in Appendix E-3. When an IAGA 2002 file is sent, the SUBJECT field should contain the correctly formatted IAGA 2002 file name. When using the IMFV1.23 Format, the SUBJECT field of the electronic mail header should contain the filename being sent as defined in IMFV1.23.

for example:

```
Subject:MAR1592.BOU
```

This indicates that a day file containing data from Boulder observatory March 15 is sent. A complete day's data is assembled into each IMFV1.23 file.

A list of GIN Internet addresses can be found in the Quick References section.

2.4 DATA ENCODING FOR SATELLITE TRANSMISSION

In preparation for transmitting data to one of several possible satellites an IMO will first prepare its data in INTERMAGNET format IMFV2.83 or later, which is fully described in Appendix E-1. This format imposes a common structure on the data files, ensuring that all necessary information is included so that the data may be properly decoded at a GIN. Once data are in IMFV2.83, a supplementary encoding step is applied to make the data stream, as transmitted to satellites, exactly compatible with the requirements of the satellite operators. Appendix E-2 shows the supplementary encoding steps for the GOES and Meteosat satellites along with examples using a specific data set. Appendix E-2 also provides provisional information about encoding for the GMS satellite.

2.5 DATA ENCODING FOR DVD/CD-ROM

Definitive data for an IMO are to be provided to INTERMAGNET shortly after the end of each calendar year (six months maximum) for inclusion in an annual INTERMAGNET DVD. The format for submission of data appears in Appendix C-1. Baseline data will accompany the definitive data, and will be provided in format IBFV2.00 or later as described in Appendix E-4. Refer to chapter 4 for a general description of the DVD/CD-ROM.

2.6 ABSOLUTE MEASUREMENTS / BASELINES

The provision of absolute control at a magnetic observatory requires a series of measurements of the absolute values of the geomagnetic field using manually operated instruments. Ideally, the frequency at which these measurements are made may vary from daily to weekly, depending on the variometer characteristics, the stability of the piers and installation and logistical considerations. The quality of the absolute control may be judged by examining the baseline corrections to the variometer data (see Appendix E-4). Some IMOs may use intermediate Reference Measurements (RM) which are more stable for inter-comparison. Chapter 6 provides a discussion of data quality control.

Several combinations of instrumentation are in use for absolute determinations, but INTERMAGNET recommends a proton precession magnetometer and a Declination/Inclination magnetometer (fluxgate mounted on a theodolite). Many factors are involved in achieving good baselines at a magnetic observatory. Some suggestions are presented in this short summary. A good adopted baseline shows a low scatter of individual baseline determinations, and has few drifts or offsets. Executive Council and Operations Committee recommend to:

1. Make weekly absolute observations, avoiding intervals of magnetic disturbance. If the baseline is changing rapidly, increase the frequency of absolute observations.

2. Make regular physical inspections of all observatory buildings to ensure that no magnetic materials which would cause jumps in baselines have been lying around, inside or outside the building.

3. Ensure that absolute instruments and their supporting piers are free from contaminating magnetic materials.

4. Set up a pier in an undisturbed area outside the absolute building; determine the absolute differences between the external pier and the main absolute pier at least once a year, to check for changes in the magnetic environment.

5. Maintain an up-to-date diary of absolute measurements, visits, repairs and other actions at the observatory.

6. Operate two variometers at the observatory and compare their data records.

7. Keep variometers, interconnecting cables, and control electronics at constant temperatures.

8. Continuously monitor and record the temperatures of all sensors, cables, and electronics units.

9. Review the procedures in use for absolute measurements at the observatory and consider if there are better procedures that could be use. INTERMAGNET recommends the use of a proton precession magnetometer and a Declination/Inclination magnetometer (fluxgate mounted on a theodolite).

10. Undertake visits between institutions by observers to encourage the exchange of ideas on instrumentation and observatory practice. Attend IAGA workshops.

11. Establish inter-observatory absolute instrument comparisons by observers, similar to the concept of the Scandinavian inter-observatory comparisons. Attend IAGA workshops.

12. Undertake better training of observers.

13. Provide meaningful information to observers about how their work contributes to local and worldwide research projects, and how baseline quality can affect the research.

This manual will not elaborate on the details of absolute techniques. However, useful articles can be found in Wienert (1970), Stuart (1984), Coles (1988), Kauristie et al. (1990), Rasson (1996), and Best and Linthe (1998). Two comprehensive manuals contain detailed sections on absolute measurement techniques. These are the "Guide for Magnetic Repeat Station Surveys" (Newitt, Barton, and Bitterly) and the "Guide for Magnetic Measurements and Observatory Practice" (Jankowski and Sucksdorff).

References:

Best, A. and Linthe, H.-J. (eds.) 1998. Proceedings of the VIIth Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing, GeoForschungsZentrum Potsdam, Scientific Technical Report STR98/21, 450p.

Coles, R.L. (ed.) 1988. Proceedings of the International Workshop on Magnetic Observatory Instruments; Geological Survey of Canada Paper 88-17, 94 p.

Jankowski, J. and Sucksdorff, C. 1996. Manual on Magnetic Measurements and Observatory Practice, International Association of Geomagnetism and Aeronomy, Boulder, Co., 235 p.

Kauristie, K., Sucksdorff, C., and Nevanlinna, H. (eds.) 1990. Proceedings of the International Workshop on Geomagnetic Observatory Data Acquisition and Processing; Finnish Meteorological Institute, Geophysical Publications No.15, 151 p.

Loubser, L. 2002. Proceedings of the Xth IAGA Workshop on Geomagnetic Instruments, Data Acquisition and Processing, 300 p.

Newitt, L.R., Barton, C.E., and Bitterly, J. 1996. Guide for Magnetic Repeat Station Surveys, International Association of Geomagnetism and Aeronomie, Boulder, Co., 112 p.

Prigancová, A., Vörös, Z., 2000. IXth IAGA Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing, Contributions to Geophysics and Geodesy, Geophysical Institute Slovak Academy of Sciences Vol. 31, No. 1, 454 p.

Rasson, J.L. (ed.) 1996. Proceedings of the VIth Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing, Dourbes, Institut Royal Meteorologique de Belgique, Publication scientifique et technique N. 003., 249 p.

Stuart, W.F.(ed.) 1984. Geomagnetic observatory and survey practice; reprinted from Geophysical Surveys, Vol. 6, nos. 3/4; D. Reidel, Dordrecht/Boston, 464 p.

Wienert, K.A. 1970. Notes on geomagnetic observatory and survey practice; UNESCO, Paris, 217 p.

CHAPTER 3 GEOMAGNETIC INFORMATION NODES - GINs

3.1 DEFINITION

In order that all INTERMAGNET data transfers may be handled efficiently, INTERMAGNET has established a number of Geomagnetic Information Nodes (GINs). The function of the GINs is to collect magnetic observatory data in near-real time, store it in a database, and forward it to the INTERMAGNET data repository from which it may be easily obtained through the web site by users of INTERMAGNET data. The GIN manager functions as a point of contact for IMOs to resolve any data transmission and formatting problems.

Geomagnetic Information Nodes have been set up in the following locations:

Golden, Colorado	- United States Geological Survey
Ottawa, Canada	- Geological Survey of Canada
Edinburgh, Scotland	- British Geological Survey
Paris, France	- Institut de Physique du Globe de Paris
Kyoto, Japan	- Kyoto University

Full GIN addresses are given at the end of this chapter. All sites are either equipped with satellite receiving equipment or receive satellite data from a satellite collecting center. All sites also have computers supporting electronic mail. This allows easy input of data from any magnetic observatory participating in INTERMAGNET. Depending on GIN location and the method used to input data, either satellite or electronic mail, observatory data are available to users from a minimum time of 12 minutes to a maximum time of 72 hours after the observatory recordings are made. If the observatory is transmitting its data through the GOES satellite links, the data reach the GIN within 12 minutes of recording. An alternative method, for observatories not equipped with satellite transmission equipment, is to input data to a GIN using electronic mail (E-Mail). To use this method an observatory must relay its data at least once every 72 hours to a GIN.

3.2 FUNCTIONS AND RESPONSIBILITIES

When observatory data are relayed to a GIN the format of these data may be either IAGA 2002, INTERMAGNET Format IMFV2.83 or INTERMAGNET GIN Dissemination Format for Minute Values IMFV1.23, or subsequent versions. The IMFV2.83 format is used for data transmitted through a satellite link, the IAGA 2002 and IMFV1.23 format for data input via an E-Mail message.

Once the data have been received the first process carried out by the GIN is to convert the IMFV2.83 format data to IMF V1.23 format and to designate them as REPORTED data. The second process is to forward these data files onto the INTERMAGNET data repository.

Each GIN will, as a routine daily task, produce stackplots of data received from all input sources. These are used as a quality assurance guide on the operation of each contributing observatory. No attempt will be made at any GIN to modify any REPORTED data input to it, but a GIN may apply spike removal routines to REPORTED data to produce other files from which stackplots are produced.

IMFV1.23 data can exist in one of three forms:

1) REPORTED Data - Data as input from an observatory, transmitting through a satellite or using E-Mail. REPORTED data have not had any baseline corrections applied, they may contain spikes and may have missing values.

2) ADJUSTED Data - Each observatory or its parent institute is allowed to modify REPORTED data files to produce ADJUSTED data, with a goal of 7 days after transmission. These adjustments may be to modify baselines, remove spikes or fill gaps, etc. on any day file. When data are missing from an ADJUSTED data file, these data may be input to a GIN in a later message. This new message file can be transmitted to a GIN with the 'A' flag set in byte 25 of each hourly block header. ADJUSTED data are maintained online until the annual DVD is available. They are then archived by the GIN and are only available thereafter by special arrangement.

3) DEFINITIVE Data - This describes observatory data which have been corrected for baseline variations, have had spikes removed and gaps filled where possible. DEFINITIVE data have each block header byte 25 in format IMFV1.23 set to 'D', and the quality of the data is such that in this form they would be used for inclusion into Observatory Year Books, input to World Data Centers and included on the annual INTERMAGNET DVD.

3.3 DATA TRANSMISSION FORMATS

In order that all INTERMAGNET data relayed between GINs and participating institutes share common standards, a series of GIN data formats have been developed by the INTERMAGNET Operations Committee. All data transfers between GINs and IMOs are in these formats, and a GIN will not accept data from any INTERMAGNET participant unless they adhere strictly to the defined formats.

1) IAGA 2002 or IMFV1.23 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

These define the formats in which observatory minute data may be input to a GIN by electronic mail. These formats are fully defined and described in Appendix E-3 and Appendix E-5.

2) INTERMAGNET GIN FORMAT FOR MAGNETIC INDICES

Details of this format have yet to be formulated by the INTERMAGNET Operations Committee. An addendum to this manual will be prepared when this format has been defined.

3.4 USER ACCESS TO GINs

GINs are responsible for data from the observatories listed in Appendix B-2. User access to the GINs is limited to the observatories who send their data to a given GIN. The access method is established separately by each GIN.

The complete INTERMAGNET data set for all participating observatories is very large. The entire data base is located on the primary INTERMAGNET web server.

Public access to INTERMAGNET data is provided through the INTERMAGNET web site only. See Chapter 7 for more information on INTERMAGNET's web sites and data.

3.5 GIN MANAGER ADDRESSES

Any enquiries to individual GINs should be made to the INTERMAGNET GIN Manager at the following addresses:

USGS - USA:
Duff C. Stewart
U.S. Geological Survey
Box 25046 MS 966
Denver Federal Center
Denver, Colorado 80225-0046
USA
Telephone: 1-303-273-8485
Fax: 1-303-273-8506
Internet: gol_manager@ghtmail.cr.usgs.gov

GSC - Canada:
David Calp
Geological Survey of Canada
Geophysics Division
7 Observatory Crescent
Ottawa, Ontario
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Telephone: 1-613-837-1757
Fax: 1-613-824-9803
Internet: ottmanager@geolab.nrcan.gc.ca

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Geomagnetism Team
British Geological Survey
Murchison House
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Edinburgh EH9 3LA
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Fax: 44-131-667-1877
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Fax: 33 (0) 1-71-93-77-09
Internet: p_ginman@ipgp.fr

Kyoto University - Japan:
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Data Analysis Center for Geomagnetism and Space Magnetism
Graduate School of Science, Bldg #4
Kyoto University
Oiwake-cho, Kitashirakawa, Sakyo-ku
Kyoto 606-8502
JAPAN
Telephone: 81-75-753-3959
Fax: 81-75-722-7884
Internet: imagmanager@swdcdb.kugi.kyoto-u.ac.jp

3.6 GIN INTERNET ADDRESSES

ottgin@geolab.nrcan.gc.ca
par_gin@ipgp.fr
gol_gin@ghtmail.cr.usgs.gov
e_gin@mail.nmh.ac.uk
kyoto-gin@swdcdb.kugi.kyoto-u.ac.jp

CHAPTER 4 THE INTERMAGNET DVD/CD-ROM

4.1 INTRODUCTION

In January 1992 the Executive Council and Operations Committee decided to produce a CD-ROM of definitive minute data values from observatories of participating institutions, beginning with 1991 data and continuing annually thereafter. Users thus have access to global magnetic observatory data near-real time values and also the final, definitive data. Within six months after the end of the year the institution responsible for an IMO must deliver a complete set of definitive data (after de-spiking, padding of missing values, application of corrected baselines and other processing procedures) and samples of baseline data to be included on the annual INTERMAGNET DVD/CD-ROM.

The INTERMAGNET DVD/CD-ROM only contains data from participating observatories. Participating observatories are those that meet the INTERMAGNET standards and also report their data to a GIN within 72 hours of recording. The data from all contributing observatories were provided by the institutions responsible for those observatories.

4.2 GENERAL FEATURES

The first INTERMAGNET CD-ROM contains data from 41 observatories provided by 11 countries for the year 1991. These countries are Australia, Canada, Denmark, Finland, France, Hungary, Japan, Russia, Sweden, the United Kingdom, and the United States. The 1992 and later DVD/CD-ROMs also contain baseline data for the year for each observatory in the form of text and plots. Appendix B-1 of this manual provides a list of observatories currently contributing to the DVD, and Appendix B-2 gives a map showing their locations.

The DVD/CD-ROM itself conforms to the ISO 9660 standards, and only requires a DVD/CD-ROM reader with drive extensions that meet these standards to be operational. However, the access software (see below) requires several basic items, which include:

1. An IBM PC/AT or compatible microcomputer.
2. 640 Kilobytes (Kb) of memory.
3. MS-DOS or PC-DOS, version 3.1 or higher operating system.
4. Video Graphics Adapter (VGA) with at least 256 Kb of graphics memory.
5. An optional Epson-compatible dot matrix, or Hewlett-Packard Laserjet-compatible laser printer.

4.3 IAF INTERMAGNET ARCHIVE FORMAT (DVD/CD-ROM)

INTERMAGNET has published CDs and DVDs of geomagnetic observatory data since 1991. The CDs and DVDs contain a variety of metadata, including contact information and quality control records. The geomagnetic data on the CDs and DVDs is held in INTERMAGNET archive format. This format holds minute, hourly and daily mean values as well as K indices.

The data are coded as 32-bit (long integer) binary words, with 5888 words comprising a day-long record. Each file contains one month of day-records (so files are variable length, from 28 to 31 records). Each day of data has a header and data section, the data being subdivided into minute means, hourly means, daily means and a set of K-indices. To date, four versions of this format have been used: IAFV1.00 being the original description of the format. It was only designated as version 1.00 in 2007. Minor undocumented changes were made to how the header was used over the lifetime of this version. IAFV1.10 was defined in 2008 to add the publication date, encoding of the format version number and to reserve word 16 in the header, affecting words 14, 15 and 16. In 2009, delta-F was introduced in IAFV2.00 affecting words 6,8 and 15 in the header, and words 4337 to 5776, words 5849 to 5872 and word 5876 in the data section. Also in IAFV2.00, space padding was specified to be at the left most position affecting word 13 in the header and words 5885 to 5888 in the data section were made available for each contributing institution. In 2010, IAFV2.10 was defined to allow for a missing instrument designator affecting words 6 and 15 in the header, and words 4337 to 5776 in the data section. Appendix C-1 provides a schematic representation of the record structure.

4.3.1 IAFV2.10 (2010 and after)

Words 1 to 16 comprise the header section containing a mixture of text and numeric fields, including a 3-letter observatory identification preceded with a space [hex20] (ID) code, the year concatenated with the day of the year, co-latitude, longitude, elevation, reported orientation, originating organization, a D-conversion factor, data quality, instrumentation, K-9, sampling rate, sensor orientation, publication date and format version. From 2010 onward, the orientation codes "XYZ" and "HDZ" have been added to "XYZG" and "HDZG" where "G" represents ΔF (see description below). These new codes indicate that the observatory is recording 3 elements only (no scalar instrument). The D-conversion factor is a fixed value used only in the graphics portion of the access software to allow Declination to be plotted in minutes of arc and equivalent nanoteslas (nT). It is given as H/3438*10000, where H is the annual mean value of the horizontal intensity. Example: If H is 16500 D will be 47993(Integer). When XYZG or XYZ is used, the D-conversion factor should be set to 10000.

ASCII values, such as the observatory ID and orientation, are also stored as 32-bit words, but are coded as the hexadecimal byte-string corresponding to the ASCII string. For example, the string "HDZF" is coded as the sequence "48 44 5A 46". Where a string is shorter than four bytes, it is padded to the left with spaces. For example, the string "ESK" is coded as the sequence "20 45 53 4B".

Word 11 is the K-9 value for the observatory in nT, word 12 is the digital sampling rate in msec, and word 13 is the sensor orientation. Sensor orientation could be XYZF, DIF, UVZ, HDZ, HDZF etc. and should indicates which components are actually measured. If a three component sensor orientation is used, a space must be added to the left. Word 14 is the publication date encoded as 4 ASCII bytes "YYMM" provided by INTERMAGNET. The high byte (left most) of word 15 is the INTERMAGNET Archive Format version number code provided by the IMO. It takes the form of a binary single byte number ranging from 0 to 255. Zero (0x00) represents version 1.00, one (0x01) represents version 1.10, two (0x02) represents version 2.00 and three (0x03) represents version 2.10. The other three bytes of word 15 are reserved for future use and padded with zeros. Word 16 is reserved for future use.

Words 17-5776 contain the minute values of the 4 geomagnetic elements (successively X,Y,Z,G or H,D,Z,G or X,Y,Z, or H,D,Z) for the day. From 2009 onward, the 4th element contains the difference between the square root of the sum of the squares of the variometer components, F(v), and the total field from an independent scalar recording, F(s). This difference, ΔF, is defined as F(v) - F(s). Both F(v) and F(s) must be corrected to the location in the observatory where absolute geomagnetic observations are made. When F(s) is missing or both F(s) and F(v) are missing, ΔF must be set to 999999. When F(v) only is missing, ΔF must be set to -F(s). The values of the 4 elements are stored in tenth-units with an implied decimal point. Thus, an H value of 21305.6 is stored (in tenth-nT) as 213056 with a decimal point implied between the last and next-to-last digits. Words 5777-5872 are used for the hourly mean values of the successive 4 elements. From 2009 onward, words 5849-5872 always record 999999 (missing value), this is done because the 4th element in the data is a quality check for minute mean data and this quality check is meaningless for hourly means. Words 5873-5876 store the 4 daily mean values. From 2009 onward, word 5876 always record 999999 (missing value) because the quality check for daily means is also meaningless. From 2009 onward, the last 4 words (5885-5888) are available for each contributing institution. Missing data for minute, hour, and day values are stored as "999999". From 2010 onward, if a scalar instrument is not used (so no data is recorded in the fourth element) the value "888888" should be used instead of "999999". Missing K-Index values are stored as "999".

4.3.2 IAFV2.00 (2009)

Words 1 to 16 comprise the header section containing a mixture of text and numeric fields, including a 3-letter observatory identification preceded with a space [hex20] (ID) code, the year concatenated with the day of the year, co-latitude, longitude, elevation, reported orientation, originating organization, a D-conversion factor, data quality, instrumentation, K-9, sampling rate, sensor orientation, publication date and format version. From 2009 onward, the orientation must be "XYZG" or "HDZG" where "G" represents ΔF (see description below). The D-conversion factor is a fixed value used only in the graphics portion of the access software to allow Declination to be plotted in minutes of arc and equivalent nanoteslas (nT). It is given as H/3438*10000, where H is the annual mean value of the horizontal intensity. Example: If H is 16500 D will be 47993(Integer). When XYZG is used, the D-conversion factor should be set to 10000.

ASCII values, such as the observatory ID and orientation, are also stored as 32-bit words, but are coded as the hexadecimal byte-string corresponding to the ASCII string. For example, the string "HDZF" is coded as the sequence "48 44 5A 46". Where a string is shorter than four bytes, it is padded to the left with spaces. For example, the string "ESK" is coded as the sequence "20 45 53 4B".

Word 11 is the K-9 value for the observatory in nT, word 12 is the digital sampling rate in msec, and word 13 is the sensor orientation. Sensor orientation could be XYZF, DIF, UVZ, HDZ, HDZF etc. and should indicates which components are actually measured. If a three component sensor orientation is used, a space must be added to the left. Word 14 is the publication date encoded as 4 ASCII bytes "YYMM" provided by INTERMAGNET. The high byte (left most) of word 15 is the INTERMAGNET Archive Format version number code provided by INTERMAGNET. It takes the form of a binary single byte number ranging from 0 to 255. Zero (0x00) represents version 1.00, one (0x01) represents version 1.10 and two (0x02) represents version 2.00. The other three bytes of word 15 are reserved for future use and padded with zeros. Word 16 is reserved for future use.

Words 17-5776 contain the minute values of the 4 geomagnetic elements (successively X,Y,Z,G or H,D,Z,G) for the day. From 2009 onward, the 4th element contains the difference between the square root of the sum of the squares of the variometer components, F(v), and the total field from an independent scalar recording, F(s). This difference, ΔF, is defined as F(v) - F(s). Both F(v) and F(s) must be corrected to the location in the observatory where absolute geomagnetic observations are made. When F(s) is missing or both F(s) and F(v) are missing, ΔF must be set to 999999. When F(v) only is missing, ΔF must be set to -F(s). The values of the 4 elements are stored in tenth-units with an implied decimal point. Thus, an H value of 21305.6 is stored (in tenth-nT) as 213056 with a decimal point implied between the last and next-to-last digits. Words 5777-5872 are used for the hourly mean values of the successive 4 elements. From 2009 onward, words 5849-5872 always record 999999 (missing value), this is done because the 4th element in the data is a quality check for minute mean data and this quality check is meaningless for hourly means. Words 5873-5876 store the 4 daily mean values. From 2009 onward, word 5876 always record 999999 (missing value) because the quality check for daily means is also meaningless. From 2009 onward, the last 4 words (5885-5888) are available for each contributing institution. Missing data for minute, hour, and day values are stored as "999999". Missing K-Index values are stored as "999".

4.3.3 IAFV1.10 (2008)

Words 1 to 16 comprise the header section containing a mixture of text and numeric fields, including a 3-letter observatory identification preceded with a space [hex20] (ID) code, the year concatenated with the day of the year, co-latitude, longitude, elevation, reported orientation, originating organization, a D-conversion factor, data quality, instrumentation, K-9, sampling rate, sensor orientation, publication date and format version. The orientation must be "XYZF" or "HDZF". If the F element is not measured, it must be filled with 999999 in the data section. The D-conversion factor is a fixed value used only in the graphics portion of the access software to allow Declination to be plotted in minutes of arc and equivalent nanoteslas (nT). It is given as H/3438*10000, where H is the annual mean value of the horizontal intensity. Example: If H is 16500 D will be 47993(Integer). When XYZF is used, the D-conversion factor should be set to 10000.

ASCII values, such as the observatory ID and orientation, are also stored as 32-bit words, but are coded as the hexadecimal byte-string corresponding to the ASCII string. For example, the string "HDZF" is coded as the sequence "48 44 5A 46".

Word 11 is the K-9 value for the observatory in nT, word 12 is the digital sampling rate in msec, and word 13 is the sensor orientation. Sensor orientation could be XYZF, DIF, UVZ, HDZ, HDZF etc. and should indicates which components are actually measured. If a three component sensor orientation is used, a space must be added at the end. Word 14 is the publication date encoded as 4 ASCII bytes "YYMM" provided by INTERMAGNET. The high byte (left most) of word 15 is the INTERMAGNET Archive Format version number code provided by INTERMAGNET. It takes the form of a binary single byte number ranging from 0 to 255. Zero (0x00) represents version 1.00 and one (0x01) represents version 1.10. The other three bytes of word 15 are reserved for future use and padded with zeros. Word 16 is reserved for future use.

Words 17-5776 contain the minute values of the 4 components (successively X,Y,Z,F or H,D,Z,F) for the day. The 4th component "F" should be included only if it is measured from a scalar instrument independent of the other 3 components otherwise it must be filled with 999999. The values of the 4 components are stored in tenth-units with an implied decimal point. Thus, an H value of 21305.6 is stored (in tenth-nT) as 213056 with a decimal point implied between the last and next-to-last digits and a D value of 527.6 is stored (in tenth-minutes) as 5276 also with a decimal point implied between the last and next-to-last digits. Words 5777-5872 are used for the hourly mean values of the successive 4 components. Words 5873-5876 store the 4 daily mean values. Words 5877-5884 contain the K-Index*10. The last 4 words (5885-5888) are reserved for future use and padded with zeros. Missing data for minute, hour, and day values are stored as "999999". Missing K-Index and Ak values are stored as "999".

4.3.4 IAFV1.00 (2007 and before)

Words 1 to 16 comprise the header section containing a mixture of text and numeric fields, including a 3-letter observatory identification preceded with a space [hex20] (ID) code, the year concatenated with the day of the year, co-latitude, longitude, elevation, reported orientation, originating organization, a D-conversion factor, data quality, instrumentation, K-9, sampling rate and sensor orientation. From 1991 to 2005, the fourth component is the total field from either a scalar (independent) instrument or the total field calculated from the main observatory instrument. INTERMAGNET has a list of which observatories supplied which type of total field value between 1991 and 2005 and this list is available as a spreadsheet in the archive viewer software. The D-conversion factor is a fixed value used only in the graphics portion of the access software to allow Declination to be plotted in minutes of arc and equivalent nanoteslas (nT). It is given as H/3438*10000, where H is the annual mean value of the horizontal intensity. Example: If H is 16500 D will be 47993(Integer). This conversion factor only applies to HDZ observatory data supplied before 2005.

ASCII values, such as the observatory ID and orientation, are also stored as 32-bit words, but are coded as the hexadecimal byte-string corresponding to the ASCII string. For example, the string "HDZF" is coded as the sequence "48 44 5A 46".

Word 11 is the K-9 value for the observatory in nT, word 12 is the digital sampling rate in msec, and word 13 is the sensor orientation. Sensor orientation could be XYZF, DIF, UVZ, HDZ, HDZF etc. and should indicates which components are actually measured. If a three component sensor orientation is used, a space must be added at the end. Word 14-15 are reserved for future use and padded with zeros. In version 1.10 and later, word 15 have been defined to represent the version number. Previously, it should have been coded to zero by IMOs, that is the reason this word was chosen for the version number (zero represents version 1.00). Word 16 is set aside for each contributing institution to use as they wish, provided it is coded as a 32-bit binary value.

Words 17-5776 contain the minute values of the 4 components (successively X,Y,Z,F or H,D,Z,F) for the day. Until 2005, the 4th component could contain "F" from either a scalar or calculated from the vector instrument. From 2006 onward, the 4th component contains "F" only if it is measured from a scalar instrument independent of the other 3 components otherwise it must be filled with 999999. The values of the 4 components are stored in tenth-units with an implied decimal point. Thus, an H value of 21305.6 is stored (in tenth-nT) as 213056 with a decimal point implied between the last and next-to-last digits and a D value of 527.6 is stored (in tenth-minutes) as 5276 also* with a decimal point implied between the last and next-to-last digits. Words 5777-5872 are used for the hourly mean values of the successive 4 components. Words 5873-5876 store the 4 daily mean values. Prior to the 1994 CD-ROM, words 5877-5884 held the 8 (K-Index*10) values for the day. The true IAGA K-Index could be obtained from these K-Index*10 values by truncating the second (least significant) digit. From 1994 onward, words 5877-5884 contain the K-Index*10. Until 1998, word 5885 contained the equivalent daily amplitude index (Ak). From 1999 onward, word 5885 is reserved for future use and padded with zeros. The last 3 words (5886-5888) are reserved for future use and padded with zeros. Missing data for minute, hour, and day values are stored as "999999". Missing K-Index and Ak values are stored as "999".

4.4 STORAGE REQUIREMENTS

Each 1-day record requires 23,552 bytes, so a month-file for January would require 730,112 bytes of storage. A year of observatory data requires almost 8.6 Megabytes (Mb) of storage. The storage capacity of a CD-ROM is about 640 Mb. A single sided, single layer DVD holds about 4.7 Gb, a single sided, double layer DVD about 8.5Gb.

4.5 INTERMAGNET DVD/CD-ROM DIRECTORY STRUCTURE

The files on the INTERMAGNET DVD/CD-ROM are set up in a particular directory structure. The root directory contains a "README.TXT" file, which is an ASCII file describing the DVD/CD-ROM and where to obtain information about it, the software, and documentation; CDs also hold a "README.EXE" file, which is an executable version of the README.TXT file that allows the user to scroll back and forth through the information.

On the 1991 CD-ROM there are also two sub-directories. One is labelled "XTRAS", and the other "MAG1991". The XTRAS directory contains one file labeled "STRUCTUR.DAT", and another "PRNSTRUC.EXE". The STRUCTUR.DAT file provides a schematic of the data structure for the records on the DVD/CD-ROM and the PRNSTRUC.EXE file enables the user to obtain a printout of that record structure.

The MAG1991 directory contains a sub-directory for each observatory identified by its 3-letter ID code. In addition, there are sub-directories labeled "1991MAPS", "CTRY_INF", and "OBSY_INF". The 1991MAPS directory contains the *.PCX files that are the map images of each country for use in the access software. These are labeled by a 3-letter country ID with the PCX extension, and one labeled "ALL.PCX" for the "All Countries" option. The CTRY_INF directory contains a "CTRYLIST.IDX" file that is used internally, *.PCX files for each country (and one for ALL) that are the images used to show the flag and organizational Logo for the different countries, and the README files that pertain to each country's geomagnetism program (including a README for the ALL option). The OBSY_INF subdirectory contains a "91OBSYDAT.DBF" file that is used internally in the software.

The individual sub-directories (e.g. BFE for Brorfelde, TUC for Tucson, etc.) contain the 12 months of data labeled with the 3-letter ID, 2-character year, 3-letter month abbreviation, and a "BIN" extension indicating they are binary files. For example, "BFE91AUG.BIN" is a file of 31 sequential day-records for Brorfelde, for

1991, for August. In addition, there are the "README.XXX" files for the individual observatory, where the XXX indicates the 3-letter observatory ID.

This sub-directory may also contain a file labeled as XXXYRK.DKA, where the XXX is the 3-letter observatory ID, the YR is the 2-character year value and the K indicates a K-Index file. Originally the DKA extension was used to indicate that the data were generated from a digital algorithm in an ASCII format, however subsequently these files have been used to hold both digitally derived and hand-scaled K indices. Since the 2005 CD-ROM the DKA files have been created by INTERMAGNET using data from the binary IAF file (before 2005 these files were provided by the observatories). These ASCII K-Index files are used, even though the data are in the binary records, because they are much faster to access than paging through the binary records on the DVD/CD-ROM.

4.6 INTERMAGNET CD-ROM SOFTWARE

The INTERMAGNET CD-ROM software is a menu-driven program that allows the user to display data in both graphics and text modes. It also allows the user to **S**ave the graphics in the form of *.PCX files that can then be imported into other programs that accept the PCX format; and also **S**ave the text in the form of ASCII files to the hard drive or floppy disk. Output may also be sent to an Epson-compatible dot-matrix, or Hewlett-Packard Laserjet-compatible printer for both plots and text.

Starting the software brings up a "Welcome" screen, and an ENTER command brings the user into the HOME screen, with menu options for YEAR, COUNTRY, OBSERVATORY, DATE-RANGE, AND MODE-OUTPUT. The "↑" and "↓" keys allow the user to scroll through the choices, which are highlighted as the user moves through them. Pressing the "ENTER" key selects the highlighted option, and activates pop-up menus with further options. All options may be selected using the ↑, ↓, and ENTER keys. Selections may also be made with the use of "Hot Keys", which are the first letter of each option, and indicated in the software by use of a different color in the menu choices. Pressing the particular Hot Key activates that menu choice immediately. Hot Keys are indicated in this manual by the use of bold type, for example, **S**(ave) means that if the "S" key is pressed for the Save option, it is executed immediately. Once all selections have been made, the EXECUTE option retrieves and displays the chosen options. Pressing the "ALT" and "E" keys simultaneously will exit the user back to DOS at any time, and from anywhere within the program.

There are 6 MODE-OUTPUT options: a) minute value plots, b) minute values as text, c) mean hourly value plots, d) mean hourly values as text, e) K-Index values as text, and f) a conversion option that converts data from the 32-bit binary format into the World Data Center (WDC) ASCII format. The WDC format option was included to allow users with existing software designed for this format to output the desired data and import it into their existing programs.

Help screens are available throughout the program with the use of the "F1" key. When the user is in a particular highlighted menu item, the F1 key provides a help screen about that item. In addition, information screens are available about a particular country using the "F4" key, and about the particular observatory using the "F3" key. These option keys appear on a menu bar on the screen when the COUNTRY and/or OBSERVATORY option is highlighted. The user can scroll through these README screens using the "↑" and "↓" keys, once the F3 or F4 key has been pressed.

Within the program, menu bars located at the top and bottom of the screen, offer a variety of options. A map screen of each country is available, showing the observatories contributing to the CD-ROM from that country, by using the **V**(iew map) key once the particular country has been chosen. Also, an **A**(bout) screen is available for each country showing the organization's address and the names of persons to contact regarding their geomagnetism program. Users can change observatories (within a given country) and date ranges while in the output mode without having to return to the HOME screen. Individual components in the plot outputs may be selected and displayed at an enlarged scale using the **C**(omponent) option (Hot Key "C") from the menu bar. While in the Component mode, the **T**(oggle) key toggles on and off a histogram of hourly means and K-Index values (when available) for the minute plots, and the Ak values for the mean hourly values plots. **P**(rint) and **S**(ave) options are also available for both graphics and text modes. Starting with the 1992 CD-ROM, a Base(**l**)ine option was made available that provides absolutes and baseline calibration data for each station. These data can be viewed either in the form of a plot for each component, or in text mode showing the observed and adopted values for the year. The plots also show a delta-F plot of the differences between the observed and computed total field (F) for some stations; and the text mode contains a comments section pertaining to baseline jumps and other observatory adjustments.

Other options that are available from the menu bars include a **B**(eginning day) choice that resets the output to the beginning of the selected date-range, a **F2**(Flow) chart of the software program that indicates where the user is within the program and what outputs are available, and a **R**(escale) option that allows the user to set the scale of the plots. This feature disables the auto-scaling of the plots, and enables a user to plot data at a fixed scale for comparison of different days and/or observatories on the same full-range scale. However, if the data cannot fit within the plot range, the Rescale option will override the user-selected scale and auto-scale to fit the data. While in the HOME screen, the **P**(references) option allows the user to customize certain parameters including the text and background colors, the type of printer being used, and the CD-ROM and output drive letter designations, it is also possible to add CRLF (carriage return / linefeed characters) to the records in any data converted to WDC-files..

Copies of DVD/CD-ROM, software and documentation may be obtained from:

INTERMAGNET DVD/CD-ROM distribution office
Observatoire Magnétique National
Carrefour des 8 routes
F-45340 Chambon la Forêt
FRANCE
Tel: 33 (0) 2-38-33-95-00
Fax: 33 (0) 2-38-33-95-04
Internet: imso@ipgp.fr

CHAPTER 5 SATELLITES

5.1 GEOSTATIONARY SATELLITES

Orbiting the earth, 36,000 km above the equator with approximately 72° of longitude between them are five geostationary satellites, METEOSAT, GOES-East, GOES-West, GMS and INSAT. The operational status of the INSAT satellite, operated by the Indian Meteorological Agency is not clear at the present time, and it is not used for any INTERMAGNET tranmissions. The primary function of the other four satellites is to provide regular updates, to meteorological agencies, of cloud and infra-red image data which they use to produce forecasts of weather conditions worldwide. Along with these imaging facilities the satellites can, at regular time intervals, relay data collected from remote ground based transmitters to users equipped with suitable receiving and decoding equipment.

This method of data transmission is being used by many magnetic observatories participating in INTERMAGNET to relay data from observatories in both the northern and southern hemispheres to the INTERMAGNET GINs. Until recently, data from observatories in the southern hemisphere or remote island groups took months, or in some cases years, to reach users; but now, using satellite communications, data from an Antarctic island are available to researchers from an INTERMAGNET GIN within 72 hours of recording.

5.2 METEOSAT

Transmitting through METEOSAT, each Data Collection Platform (DCP) is allocated a one-minute transmission slot every hour. During this time the DCP encodes and transmits, to the satellite, any data input to it during the previous 60 minutes. From the satellite, the data are relayed to the EUMETSAT operations center at Darmstadt, Germany, where they are checked and temporarily stored. The GIN automatically collects the data from EUMETSAT web site. For more information please contact the Paris GIN manager.

5.3 GOES

Observatories transmitting through the GOES East/West satellites output their data every 12 minutes to the satellite and in this case there is no secondary retransmission stage, as is done with METEOSAT. In the GOES system the data are transmitted directly to a receiving GIN where they are made available to users. This form of communication is simpler, but the GOES link does require a much larger receiving antenna as signals transmitted directly from a geostationary satellite are at a very much lower power than those relayed using the METEOSAT retransmission facility. To overcome the necessity for a large 3-5m receiving dish antenna, users in or near the United States may also access GOES East and West transmissions using a DOMSAT (DOMestic SATellite) receiving station. This is a retransmission facility similar to that used with METEOSAT, providing users with a much stronger signal and hence a considerable reduction in the size of the receiving antenna required (1.2 - 1.8m in diameter).

5.4 TRANSMISSION ACCESS

The use of satellites and the timed-transmission slots on any of the geostationary satellites is very closely controlled. Before an observatory can transmit data using a satellite, an application must be made to the relevant controlling body. All transmission equipment used must have been checked and certified to be of an acceptable standard before a licence and a transmission slot can be granted. Also, although it may be possible to gain free access to geostationary satellites, depending on the institute and the use to which the data are being put, the satellite operators may charge users for access.

Two different types of transmission authority may be necessary before an observatory can transmit its data through a satellite to a GIN:

1) Authority to transmit to an Earth orbiting apparatus. This is a licence issued by the government of a particular country which gives an institute permission to operate radio transmission equipment. This type of licence may not be necessary, but prospective participants should check with their respective government departments to ensure that they are not contravening any transmission laws in force in their country.

2) Application must be made to the operators of the satellite which can be accessed from the observatory. Appendix B-2 shows the footprints of geostationary satellites and from this users can decide which satellite should provide the best transmission path. Since satellite positions are sometimes changed, those intending to operate an IMO near the edge of a footprint should contact the satellite operators for more detailed information concerning the satellite accessibility. Most satellite operators have a standard application form. A prospective user should write

to the operator giving details of the proposed use to which the transmitted data is to be put, a brief description of the project and a request for a transmission slot application form.

If an application form has to be completed, it may include many questions about the operator, site location, and technical questions about the type of DCP, transmission power and whether or not the proposed DCP has been certified for use on this satellite by the satellite operators. To answer these questions, it is usually necessary to contact the DCP supplier.

The completed form is then sent to the respective satellite operator, who, after due deliberation will hopefully issue the applicant with a satellite identification number, a transmission frequency/channel and a specific time slot on the allocated channel.

Alternatively, if the user or the organization to which the user belongs is a member of the World Meteorological Organization (WMO), access to a specific satellite and a transmission slot may be granted simply by quoting an identification number which has been issued by the respective satellite operators to the member state or country.

The length of time slots used varies depending on the satellite which is being accessed. A METEOSAT time slot is 1 minute every hour. On GMS it is 90 seconds every 12 minutes and on GOES, 20 seconds every 12 minutes. During these times users transmit their data. It is essential that the DCP clocks maintain accurate timing, as any transmission outside the allocated time slot will result not only in corruption of the data being transmitted, but also of data transmitted by users on adjacent time slots.

5.5 SATELLITE OPERATORS

1) METEOSAT

EUMETSAT
AM Kavalleriesand 31
D-64295
Darmstadt
Germany
Telephone: 49 61 51 80 77
FAX: 49 61 51 80 75 55
INTERNET: ops@eumetsat.de
WEB: www.eumetsat.de

Those whose potential IMOs would be serviced by METEOSAT are advised to first contact the PARIS GIN operator for timely information on access to METEOSAT.

2) GOES East and West

Mr. Jim Abeyta
NOAA R/E/SE
325 Broadway
Boulder, CO 80303
USA
Telephone: 1-303-497-5827
Internet: James.Abeyta@noaa.gov

Those whose potential IMOs would be serviced by GOES are advised to first contact the GOLDEN GIN operators for timely information on access to GOES.

5.6 SATELLITE SERVICES

Other methods of obtaining permission to transmit via METEOSAT and GOES East and West are:

1) Through MAEDS (Multisatellite Applications Extended Dissemination Service), which is a commercial organization based in France. This company undertakes to arrange a satellite transmission slot on METEOSAT and GOES.

CLS Service MEADS
18, Av. Edouard Belin
Toulouse Cedex 31055
FRANCE

2) Through North American Collection and Location Service (NACL), which is a company providing similar services to those provided by MAEDS.

Mr. Peter Griffith
North American Collection & Location by Satellite
9200 Basil Court, Suite 306
Landover, MD 20785
USA
Telephone: 1-301-341-1814
Fax: 1-301-341-2130

These companies have been given the right by EUMETSAT to market environmental data gathering services.

CHAPTER 6 DATA QUALITY CONTROL

6.1 INTRODUCTION

Quality control methods should be employed in the production of reported, adjusted and definitive data. Total field intensity values that are recorded using a proton precession magnetometer are an excellent tool for monitoring the measurement process that produces component values. The total field values may also be used to estimate the maximum likely range of error for component values. Baseline values are used to adjust component values for long- period, non-random error. A baseline adoption process may be used that provides confidence limits for component 1-minute values. A tabular listing of annual baseline values and a description of baseline adjustments accompany data contained on INTERMAGNET DVDs/CD-ROMs. A graphic display of baselines and differences in computed and recorded total field values are available to users for stations on the INTERMAGNET DVDs/CD-ROMs.

6.2 THE OBSERVATORY MEASUREMENT PROCESS

Magnetic observatories use a variety of magnetometers, electronics, and computer processes to obtain component values of the Earth's magnetic field at 1-minute intervals. The component values recorded depend on the type of variometers used and the orientation of the variometer sensors. A vector diagram of component relationships is shown in figure 1. The reliability of component values may be influenced by many factors:

- orientation of variometer sensors
- stability of variometer piers
- filter techniques used in digitizing values
- temperature coefficients of variometer sensors and electronics
- background noise of sensors and electronics
- orthogonality of variometer sensors
- application of absolute controls

The instruments, electronics, computer processes, and observatory procedures are selected to minimize the negative effects of the above factors. Quality control procedures should be used to monitor these influences.

Component baseline values are computed from absolute measurements and digitally recorded component values. Absolute values of the Earth's magnetic field are measured by an observer and the accuracy of the absolute values depend on several factors:

- observer skill and absence of bias
- calibration of magnetometers
- accuracy of pier corrections
- random error inherent in the measurement process
- pier stability
- magnetometer's susceptibility to environmental influences
- activity of the magnetic field during the measurement process
- field gradient

The non-random error in the absolute measurements should be minimized by using standard observatory procedures (see references in section 2.6).

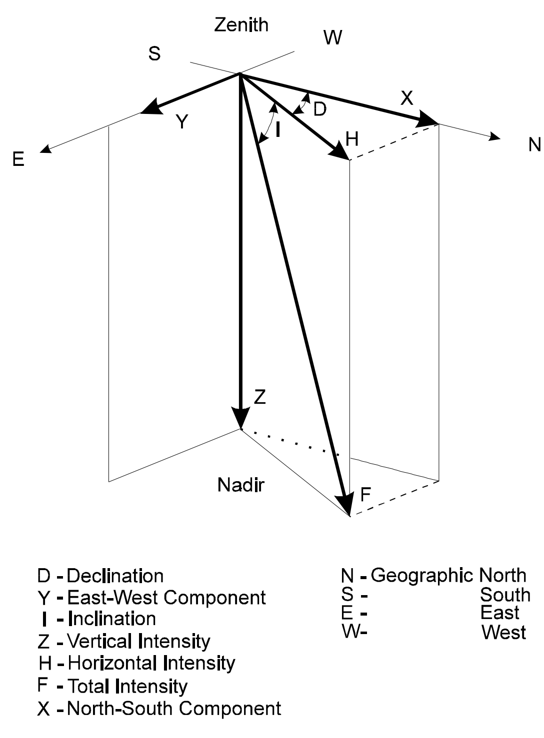


Figure 1 - Geomagnetic Components

6.3 COMPUTATION OF BASELINE VALUES

The component baseline values are reported in the format described in Appendix E-4. The general form of the equation for computing the baseline value for an arbitrary component `W', is shown below:

$$W_B(k) = W_O(i:j) - [W_S(k) * W_M(i:j)]$$

where:

- (i:j) - is the time interval (generally several minutes) for the measurement
- (k) - is the k-th time, the average time of the interval (i:j).
- W_B - is the computed baseline value
- W_O - is the observed absolute field value for time interval (i:j).
- W_S - is the scale value of component W of the variometer sensor. This value is used to convert electrical units to magnetic units. The conversion factor may be automatically applied by computer or electronics to 1-minute values. If the conversion factor is not stable, scale value measurements should be made and recorded for baseline application.
- W_M - is the mean of the 1-minute component values recorded during the time interval (i:j).

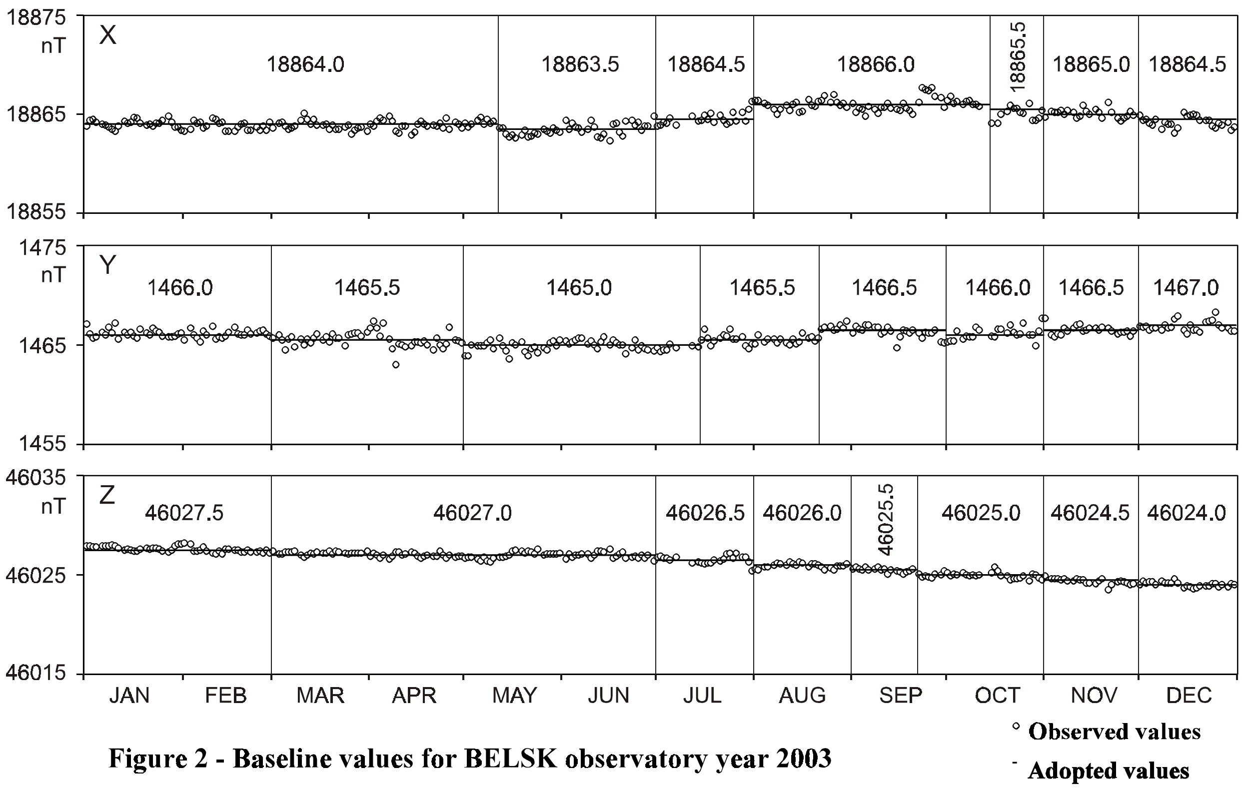


Figure 2 - Baseline values for BELSK observatory year 2003

6.4 BASELINE ADOPTION

A number of methods are used in observatory data processing procedures to adopt baselines from observed baseline values. An adopted baseline may be fitted to the baseline values by hand or by a computer algorithm. The baseline values obtained from the adopted baseline for each day are written to a file in the INTERMAGNET baseline format IBFV2.00, (Appendix E-4). The format includes a section for comments pertaining to dates and times of baseline adjustments or changes in instrumentation. These files must be transmitted annually to INTERMAGNET along with 1-minute data for DVD production.

If the baseline is adopted by computer, statistics may be generated to verify that confidence limits for the adopted baseline meet the INTERMAGNET specifications. The confidence limits are computed from the variance of baseline values about the adopted baseline for specific segments of time. Component confidence limits for the annual adopted baseline may be estimated by pooling the variance of the segments. This may provide the user with a quantitative measure of the possible error in component values.

Figure 2 shows observed values (circles) and adopted baseline values (dots) for magnetic field components X, Y, and Z for Belsk observatory during 2003. The time series of F-P total field differences, defined in section 6.5, corresponds to the time series of adopted baseline values.

6.5 THE COMPUTATION OF TOTAL FIELD DIFFERENCES

One-minute total field values should be recorded in parallel with 1-minute component values taken at the same time. The total field difference (F-P) is the total field computed from component values (baseline-adjusted) minus the total field value recorded by a total field magnetometer. The equations used for computing F-P values depend on the variometer orientation. The equation for computing F-P for a variometer oriented to measure components XYZ is:

$$(F\text{-}P)_i = [(BX_i+X_i)^2+(BY_i+Y_i)^2+(BZ_i+Z_i)^2]^{1/2} - F_i + PDF$$

and for HDZ orientation,

$$(F\text{-}P)_i = [(BH_i+HN_i)^2+HE^2+(BZ_i+Z_i)^2]^{1/2} - F_i + PDF$$

where:

- i - is the time of the difference computation. The time unit may be 1-minute, mean hourly, or daily differences.
- B - denotes the baseline value for components H, X, Y, or Z.
- F - is the total field value recorded using a total field magnetometer
- PDF - is the total field pier difference, the difference between the total field value at the sensor, and total field value at the absolute pier.
- HN - is the vector field of the horizontal intensity recorded by the H sensor, as shown in figure 3.
- HE - is the vector field of the horizontal intensity recorded by the D sensor. The change in declination (δD) is relative to the declination of the H sensor at orientation (D_o)

D_o = D_i -ATAN[$HE_i/(BH_i+HN_i)$].
D_i = absolute observed declination

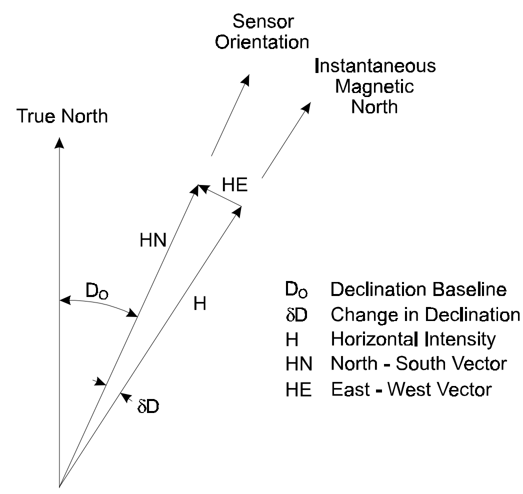


Figure 3 - Component descriptions for baselines

The F-P values may be computed from reported, adjusted or definitive data. Time series graphs of the F-P values may be produced easily and quickly at GINs. Programs may be used to produce the F-P graphs in real-time to enable GIN operators to continuously monitor the performance of those observatories transmitting to the GIN by satellite communication. The F-P values may be used for correlation studies to isolate environmental influences. The value of this technique decreases when one component dominates the others.

The errors in component values (ΔX, ΔY, ΔZ) give rise to an error in F:

$$\Delta F = \frac{X\,\Delta X}{F} + \frac{Y\,\Delta Y}{F} + \frac{Z\,\Delta Z}{F} .$$

If we assume no change in Y (ΔY) and Z (ΔZ), then the minimum detectable error that might be attributed to the X component would be: $\Delta X = F\,\Delta F/X$. The minimum detectable error may be estimated for each component. For the HDZ sensor orientation similar results arise for H and Z:

$$\Delta F = \frac{H\,\Delta H}{F} + \frac{Z\,\Delta Z}{F} .$$

No inference can be made concerning D.

6.6 SUMMARY

Tools that might be used for quality control of reported, adjusted and definitive data have briefly been described. INTERMAGNET is establishing standards of comparison such as the graphs of baselines and F-P values. Participating observatories may evaluate the performance of their operations relative to the results of other observatories. Participants communicate with other members on instrumentation procedures to improve the quality of INTERMAGNET observatory data.

CHAPTER 7 WORLD WIDE WEB

7.1 INTRODUCTION

The INTERMAGNET web site provides background information about INTERMAGNET, it's structure and it's participating organizations, countries and IMOs (INTERMAGNET Magnetic Observatories). It offers access to its various products including magnetograms and data files of Reported and Adjusted Minute Mean values from all the IMOs, the Annual DVD/CD-ROM of Definitive Data, and the Technical Reference Manual. The INTERMAGNET application form can also be obtained from the web site.

7.2 WEB SITE ADDRESS

INTERMAGNET web site address is:
www.intermagnet.org

APPENDIX A-1

INTERMAGNET TERMINOLOGY

REPORTED Data:
Data as output by an observatory, transmitting through a satellite or using E-Mail. REPORTED data have not had any baseline corrections applied, may contain spikes and may have missing values. When ADJUSTED data are available, REPORTED data are removed from online access.

ADJUSTED Data:
Each observatory or its parent institute is allowed to modify REPORTED data files to produce ADJUSTED data, with a goal of 7 days after transmission. These adjustments may be to modify baselines, remove spikes, fill gaps etc. on any day file. When data are missing from an ADJUSTED data file, these data may be input to a GIN in a later message. This new message file can be transmitted to a GIN with the 'A' flag set in byte 25 of each hourly block header (Appendix E-3). ADJUSTED data are maintained online until the annual DVD is available. They are then archived by the GIN and only available thereafter by special arrangement.

DEFINITIVE Data:
This describes observatory data which have been corrected for baseline variations and which have had spikes removed and gaps filled where possible. DEFINITIVE data have each block header byte 25 set to 'D' (Appendix E-3), and the quality of the data is such that in this form they would be used for inclusion into Observatory Year Books, input to World Data Centers and included in INTERMAGNET DVDs.

Reference Measurement (RM):
Values provided automatically by an IMO using 2 independent instruments for inter-comparison. Reference Measurements are provided by the institute operating the observatory site using satellite communications to INTERMAGNET GINs using the Format IMFV2.83. The RMs are applied to reported data to produce adjusted data and to supplement baseline control.

Magnetic observatory:
A permanent installation of magnetometers capable of providing magnetic field values with an absolute accuracy of better than 5 nT over a period ranging from DC to approximately 1 Sec.

IMO:
An INTERMAGNET Magnetic Observatory (IMO) is a magnetic observatory equipped with magnetometers, clock, control electronics, transmitting equipment and a data collection platform (DCP), residing at the magnetic observatory site. The operation and equipment must meet INTERMAGNET standards and specifications.

GIN:
A Geomagnetic Information Node contains satellite receiving equipment and computer processing facilities and is linked to communications networks. GINs collect magnetic observatory data in near real-time and store them in a database. These data, indices and other products may be readily accessed by INTERMAGNET users, usually by e-mail.

NESS binary:
For GOES users, each 16-bit binary word is encoded as 3 pseudo ASCII bytes, so that the 126 bytes of IMFV2.83 data are encoded as 189 bytes NESS binary (see Appendix E-2).

Time stamp:
The time of the first sample of the data block:

- Greenwich day 1 through 366 encoded as a 12-bit binary number.
- Minute of the Greenwich day : 0 through 1439 encoded as a 12-bit binary number (see Appendices E-1 and E-2).

Offset:
The component offset values determined by the INTERMAGNET coding algorithm that has been applied to recorded data for coding data stored in the "minute value" section of Format IMFV2.83 (see Appendix E-1).

Flags:
Two bytes "Flags #1" and "Flags #2" (bytes 8 and 9) of Format IMFV2.83, are reserved for IMO status information (see Appendix E-1).

APPENDIX B-1

OBSERVATORIES PARTICIPATING IN INTERMAGNET

OBSERVATORY ID3		IMO 2012	GEOGRAPHIC LAT	GEOGRAPHIC LON	GEOMAGNETIC LAT	GEOMAGNETIC LON	ORG	INTERMAGNET DVD/CD-ROM 1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AAA	Alma-Ata	X	43.25	76.92	34.3	152.7	IIRK															X	X	X	X
AAE	Addis Ababa	X	9.02	38.77	5.3	111.8	AAU/IPGP								X	X		X	X	X	X	X	X	X	X
ABG	Alibag	X	18.63	72.87	10.2	146.2	IIG							X	X	X	X	X	X	X	X	X	X	X	X
ABK	Abisko	X	68.36	18.82	66.1	114.7	SGU				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AIA	Akademic Vernadsky	X	-65.25	295.75	-55.0	5.5	ISRU														X	X	X	X	X
ALE	Alert		82.50	-62.35	86.9	157.1	GSC		X			X	X	X											
AMS	Martin de Vivies	X	-37.80	77.57	-46.4	144.3	EOST	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
API	Apia	X	-13.81	188.22	-15.4	262.7	DAFWS									X	X	X	X	X	X		X	X	X
AQU	L'Aquila	X	42.38	13.32	42.4	85.5	INDG									X	X	X	X	X	X	X	X	X	X
ARS	Arti	X	56.43	58.57	49.3	140.1	UBRAS																		
ASC	Ascension Island	X	-7.95	345.62	-2.4	56.6	BGS													X	X	X	X	X	X
ASP	Alice Spring	X	-23.76	133.88	-32.9	208.2	GA										X	X	X	X	X	X	X	X	X
BDV	Budkov	X	49.07	14.02	48.8	97.7	ASCR				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BEL	Belsk	X	51.84	20.79	50.2	105.2	PAS			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BFE	Brorfelde	X	55.63	11.67	55.5	81.5	DMI	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BFO	Black Forest	X	48.33	8.33	49.1	88.2	GGUKS																X	X	X
BLC	Baker Lake	X	64.33	-96.03	73.2	322.1	GSC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BMT	Beijing Ming Tombs	X	40.06	116.18	30.1	187.0	CHAS								X	X	X	X	X	X	X	X	X	X	X
BNG	Bangui	X	4.43	18.56	4.2	91.1	IRD			X	X	X	X	X	X	X	X	X	X	X		X	X	X	
BOU	Boulder	X	40.14	-105.24	48.4	320.6	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BOX	Barox	X	58.03	38.97	53.3	124.1	RAS/IPGP														X	X	X	X	X
BRW	Barrow	X	71.32	-156.62	69.6	246.2	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BSL	Bay St. Louis	X	30.35	-89.64	40.1	339.8	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
CBB	Cambridge Bay	X	69.10	-105.00	76.5	303.1	GSC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CLF	Chambon la Forêt	X	48.02	2.27	49.8	85.7	IPGP	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CMO	College	X	64.87	-147.86	65.4	261.7	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CNB	Canberra	X	-35.32	149.36	-42.7	226.9	GA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CNH	Changchun	X	44.08	124.86	34.2	195.2	CEA																		
CSY	Casey Station	X	-66.28	110.53	56.3	182.0	GA																		
CTA	Charters Towers	X	-20.08	146.25	-28.0	221.0	GA										X	X	X	X	X	X	X	X	X
CZT	Port Alfred	X	-46.44	51.90	-51.4	113.3	EOST	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DED	Deadhorse	X	70.36	211.21			USGS																		
DLR	Del Rio	X	29.50	-100.92	38.3	327.3	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DMC	Dome C	X	-75.25	124.17			EOST/INGV																		
DOU	Dourbes	X	50.10	4.60	51.4	88.9	RMIB												X	X	X	X	X	X	X
DRV	Dumont d'Urville	X	-66.37	140.01	-74.5	231.2	EOST	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DUR	Duronia	X	41.39	14.28			INGV																		
EBR	De L'Ebre	X	40.82	0.49	43.2	81.3	IGNS												X	X	X	X	X	X	X
ESK	Eskdalemuir	X	55.32	-3.20	57.8	83.8	BGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EYR	Eyrewell	X	-43.42	172.35	-47.1	253.8	IGN				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FCC	Fort Churchill	X	58.77	-94.10	68.0	328.3	GSC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FRD	Fredericksburg	X	38.20	-77.37	48.4	353.4	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FRN	Fresno	X	37.09	-119.72	43.5	305.3	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FUR	Furstenfeldbruck	X	48.17	11.28	48.4	94.6	UMUN					X	X	X	X	X	X	X	X	X	X	X	X	X	X
GCK	Grocka	X	44.30	102.30	43.3	102.4	GCG															X		X	X
GDH	Godhavn	X	69.25	-53.53	78.5	34.0	DMI	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
GLN	Glenlea		49.60	-97.10	58.6	327.8	GSC		X	X	X	X	X	X											
GNA	Gnangara	X	-31.78	115.95	-41.9	188.9	GA				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
GUA	Guam	X	13.59	144.87	5.3	215.7	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
GUI	Guimar-Tenerife	X	28.32	-16.43	33.8	60.6	IGNS							X	X	X	X	X	X	X	X	X	X	X	X
GZH	Zhaoqing	X	22.97	112.45	12.9	184.8	SBG													X	X	X	X		X
HAD	Hartland	X	51.00	-4.48	53.9	80.2	BGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HBK	Hartebeesthoek	X	-25.88	27.71	-27.1	94.4	HMO									X	X	X	X	X	X	X	X	X	X
HER	Hermanus	X	-34.43	19.23	-34.0	84.0	HMO			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HLP	HEL	X	54.60	18.82	53.2	104.6	PAS								X	X	X	X	X	X	X	X	X	X	X
HON	Honolulu	X	21.32	-158.00	21.6	269.7	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HRB	Hurbanovo	X	46.86	18.19	46.9	101.1	SAS							X	X	X	X	X	X	X	X	X	X	X	X
HRN	Hornsund	X	77.00	15.55	73.9	126.0	PAS												X	X	X	X	X	X	X
HUA	Huancayo	X	-12.05	284.67	-1.8	356.5	IGP												X	X	X	X	X	X	X
HYB	Hyderabad	X	17.41	78.56	8.7	151.9	NGRI																		

APPENDIX B-1 (Cont'd)

OBSERVATORIES PARTICIPATING IN INTERMAGNET

OBSERVATORY ID3		IMO 2012	GEOGRAPHIC LAT	GEOGRAPHIC LON	GEOMAGNETIC LAT	GEOMAGNETIC LON	ORG	INTERMAGNET DVD/CD-ROM 1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
IPM	Isla Pascua Mataveri	X	-27.17	-109.41			DMC/IPGP																		
IQA	Iqaluit	X	63.75	-68.52	74.0	5.2	GSC						X	X	X	X	X	X	X	X	X	X		X	X
IRT	Irkutsk	X	52.17	104.45	41.9	176.9	ISTPSB								X	X	X	X	X	X	X	X	X	X	X
IZN	Iznik	X	40.50	29.73	37.7	109.6	KOERI																	X	X
KAK	Kakioka	X	36.23	140.18	27.4	208.8	JMA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KDU	KAKADU	X	-12.69	132.47	-22.0	205.6	GA										X	X	X	X	X	X	X	X	X
KIV	Kiev	X	50.72	30.30	47.6	113.6	NASU																		
KMH	Keetmanshoop	X	-26.54	18.11			HMO																		
KNY	Kanoya	X	31.42	130.88	21.9	200.8	JMA											X	X	X	X	X	X	X	X
KOU	Kourou	X	5.10	-52.70	11.9	19.5	IPGP						X	X	X	X	X	X	X	X	X	X	X	X	X
LER	Lerwick	X	60.13	-1.18	62.0	89.0	BGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LNP	Lunping		25.00	121.17	15.0	192.1	MTC					X		X	X	X	X								
LOV	Lovo		59.40	17.80	57.9	106.4	SGU	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
LRM	Learmonth	X	-22.22	114.10	-32.4	186.5	GA														X	X	X	X	X
LVV	Lviv	X	49.91	23.74	47.9	107.1	IGU														X	X	X	X	X
LYC	Lycksele	X	64.61	18.75	62.7	110.9	SGU																		X
LZH	Lanzhou	X	36.10	103.84	25.9	176.1	CEA/IPGP											X	X	X	X	X	X	X	X
MAB	Manhay	X	50.30	5.68	51.4	90.1	RIMB															X	X	X	X
MAW	Mawson	X	67.60	62.88	-73.2	110.1	GA															X	X	X	X
MBC	Mould Bay		76.20	-119.40	79.9	264.8	GSC	X	X	X	X	X	X	X											
MBO	Mbour	X	14.38	-16.97	20.1	57.5	IRD			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MCQ	Macquarie	X	-54.50	158.95	-60.1	244.3	GA											X	X	X	X	X	X	X	X
MEA	Meanook	X	54.62	-113.33	61.6	306.2	GSC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MGD	Magadan	X	60.05	150.73	52.3	213.9	IKIR																		
MID	Midway	X	28.21	-177.38	25.0	249.5	USGS										X	X	X						
MMB	Memembetsu	X	43.90	144.20	35.4	211.3	JMA			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NAQ	Narssarssuaq	X	61.16	-45.44	69.9	38.6	DMI	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NCK	Nagycenk	X	47.63	16.72	46.9	99.6	HAS					X	X	X	X	X	X	X	X	X	X	X	X	X	X
NEW	Newport	X	48.27	-117.12	54.9	304.7	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NGK	Niemegk	X	52.07	12.68	51.9	97.6	GFZP			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
NUR	Nurmijarvi	X	57.70	24.70	55.9	113.2	FMI	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NVS	Novosibirsk	X	54.85	83.23	45.6	159.5	RAS														X	X	X	X	X
OTT	Ottawa	X	45.40	-75.55	55.6	355.3	GSC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PAF	Port-aux-Français	X	-49.35	70.26	-56.9	132.8	EOST	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PAG	Panagjurishte	X	42.52	24.18	40.7	105.0	BAS																	X	X
PBQ	Poste-de-la-Baleine	X	55.30	-77.75	65.5	351.8	GSC		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
PEG	Pedeli	X	30.08	23.93	36.4	103.7	IGME																		
PHU	Phuthuy	X	21.03	105.95	10.8	177.9	VAST/IPGP						X	X	X	X	X	X	X	X	X	X	X	X	X
PPT	Pamatai	X	-17.57	-149.57	-15.1	285.1	IPGP	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PST	Port Stanley	X	-51.70	302.11	-41.7	11.5	BGS													X	X	X	X	X	X
QSB	Qsaybeh	X	33.87	35.64	30.3	113.5	NCGR/IPGP										X	X	X	X	X	X	X	X	
RES	Resolute	X	74.70	-94.90	82.9	302.9	GSC		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SBA	Scott Base	X	-77.85	166.78	-79.0	290.2	IGNSL						X	X	X	X	X	X	X	X	X	X		X	X
SFS	San Fernando	X	36.67	5.95	40.1	73.2	ROA															X	X	X	X
SHU	Shumagin	X	55.35	199.53	54.3	256.8	USGS															X	X	X	X
SIT	Sitka	X	57.06	-135.33	60.4	280.4	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SJG	San Juan	X	18.11	-66.15	28.6	6.1	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SOD	Sodankyla	X	67.37	26.63	63.9	120.0	FASL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SPT	San Pablo-Toledo	X	39.55	-4.35	42.8	76.0	IGNS							X	X	X	X	X	X	X	X	X	X	X	X
STJ	St. John's	X	47.60	-52.68	57.2	24.0	GSC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SUA	Surlari	X	44.68	26.25	42.4	107.6	IGR									X	X	X	X	X	X	X	X	X	X
TAM	Tamanrasset	X	22.79	5.52	24.7	81.8	CRAAGIPGP			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TAN	Antananarivo	X	-18.92	47.55	-23.7	115.8	IOGA/EOST			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
TDC	Tristan da Cunha	X	-37.07	347.69			DTU																		
TEO	Teoloyucan	X	19.75	260.81	28.8	330.4	IGM												X	X	X	X	X	X	X
THL	Thule	X	77.47	-69.23	87.7	14.1	DMI	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
THY	Tihany	X	46.9	17.89	46.0	100.5	ELGI	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TIK	Tixie Bay		71.58	129.00	61.8	193.7	IZMIRAN	X																	
TRW	Trelew	X	-43.26	-65.38	-33.1	5.6	UNLP/RMIB										X	X	X	X	X	X	X	X	X
TSU	Tsumeb	X	-19.20	17.58	-18.8	85.9	HMO														X	X	X	X	X

APPENDIX B-1 (Cont'd)

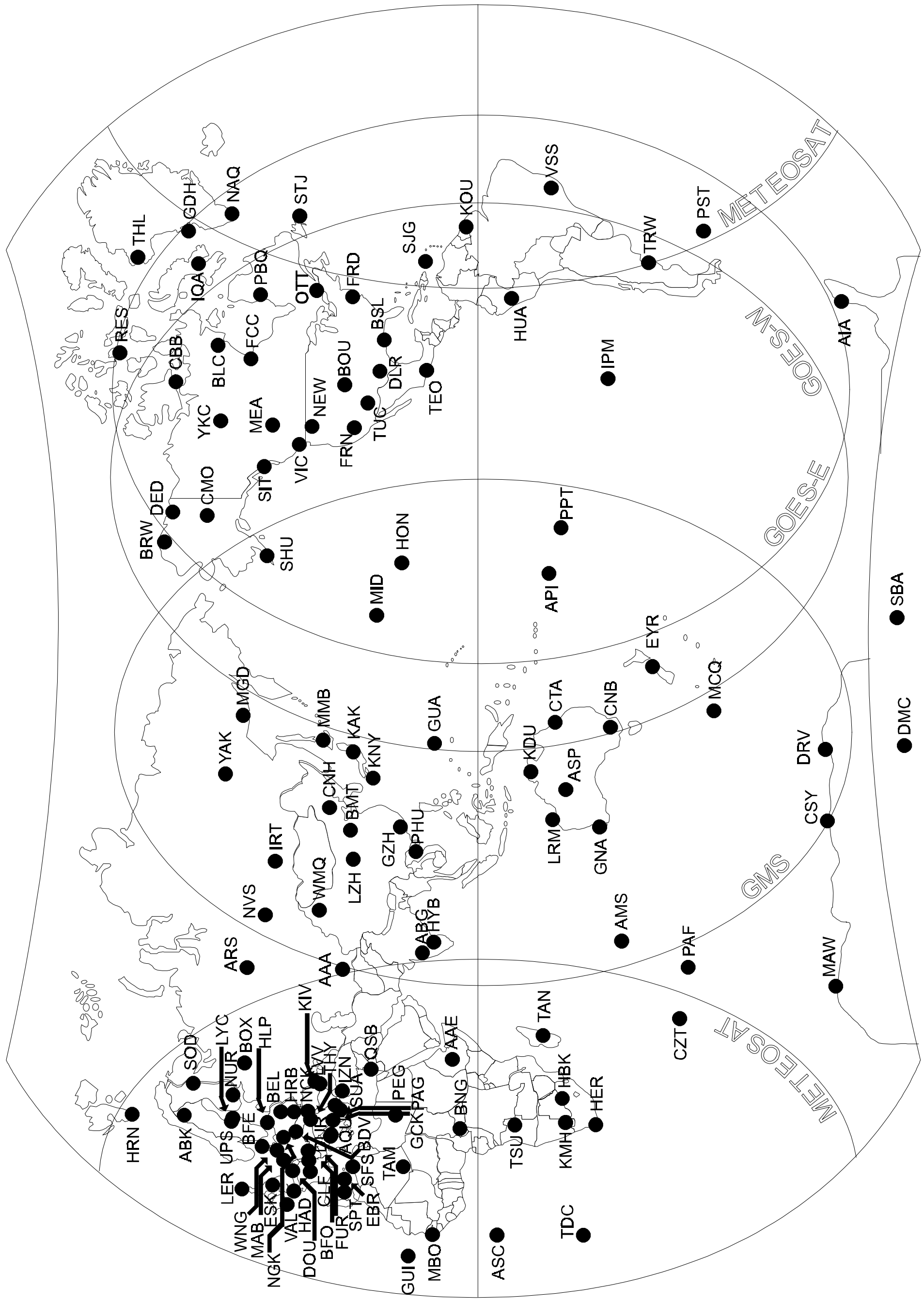
OBSERVATORIES PARTICIPATING IN INTERMAGNET

OBSERVATORY ID3		IMO 2012	GEOGRAPHIC LAT	GEOGRAPHIC LON	GEOMAGNETIC LAT	GEOMAGNETIC LON	ORG	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TUC	Tucson	X	32.18	-110.73	39.9	316.0	USGS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
UPS	Uppsala	X	59.90	17.35	58.5	106.3	SGU													X	X	X	X	X	X
VAL	Valentia	X	51.93	-10.25	55.8	74.6	IMS												X	X	X	X	X	X	X
VIC	Victoria	X	48.52	-123.42	54.1	297.6	GSC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
VSS	Vassouras	X	-22.40	-43.65	-13.3	26.6	ONB									X	X	X	X	X	X	X	X	X	X
WMQ	Urumqi	X	43.81	87.71	34.3	162.5	CEA																		
WNG	Wingst	X	53.74	9.07	54.1	95.0	GFZP				X	X	X	X	X	X	X	X	X	X		X	X	X	X
YAK	Yakutsk	X	61.96	129.66	52.6	196.8	ICRA																		
YKC	Yellowknife	X	62.47	-114.47	68.9	299.4	GSC		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	TOTAL	129					TOTAL	41	44	52	56	61	64	69	70	75	80	83	89	92	96	102	99	104	102

AAU - Addis Ababa University
ASCR - Academy of Sciences of the Czech Republic
BAS - Bulgarian Academy of Sciences
BGS - British Geological Survey
CEA - China Earthquake Administration
CHAS - Chinese Academy of Sciences
CRAAG - Centre de Recherche en Astronomie, Astrophysique et Géophysique d'Algérie
DAFWS - Dept of Agriculture and Fisheries Western Samoa
DMC - Direccion meterologica de Chile
DMI - Danish Meteorological Institute
DTU - Denmark Technical University
ELGI - Eotvos Lorand Geophysical Institute
EOST - Ecole et Observatoire des Sciences de la Terre, Strasbourg
FASL - Finnish Academy of Science and Letters
FMI - Finnish Meteorological Institute
GA - Geoscience Australia
GCG - Geomagnetic College Grocka
GFZP - GeoForschungsZentrum Potsdam
GGUKS - Geowissenschaftliches Gemeinschaftsobservatorium der Universitaeten Karlsruhe und Stuttgart
GSC - Geological Survey of Canada
HAS - Hungarian Academy of Science
HMO - Hermanus Magnetic Observatory
ICRA - Institute of Cosmophysical Research and Aeronomy, Russia
IGM - Instituto de Geofisica, Mexico
IGME - Institute of Geology and Mineral Exploration, Grrece
IGN - Institute of Geological and nuclear Sciences, New Zealand
IGNS - Instituto Geografico Nacional, Spain
IGNSL - Institute of Geological and Nuclear Sciences Limited
IGP - Instituto Geofisico del Peru
IGR - Geological Institute of Romania
IGU - Institute of geophysics, Ukraine
IIG - Indian Institute of Geomagnetism
IIRK - Institute of the Ionosphere of Republic Kazakhstan
IKIR - Institute of Cosmophysical Researches and Radio Wave Propagation, Russia
IMS - Irish Meteorological Service
INDG - Istituto Nazionale Di Geofisica, Italy
INGV - Instituto Nazionale di Geofisica e Vulcanologia, Italy
IOGA - Institut et Observatoire Géophysique d'Antananarivo, Université d'Antananarivo
IPGP - Institut de Physique du Globe de Paris
ISTPSB - Institute of Solar-Terrestrial Physics of Siberian
IRD - Institut de Recherche pour le développement, Paris
ISRU - Institute of Space Research, Ukraine
IZMIRAN - Institut Zemnovo Magnetisma Ionosfery I Rasprostranyenia Ridiovoln
JMA - Japan Meteorological Agency
KOERI - Kandilli Observatory and Earthquake Research Institute
LISCSB - Lanzhou Institute of Seismology, China Seismological Bureau
MTC - Ministry of Transportation and Communications, China (Taiwan)
NASU - Institute of Geophysics NAS of Ukraine
NCGR - National Center for Geophysical Research, Beirut Lebanon
NGRI - National Geophysical Research Institute, Uppal Roa
ONB - Observatorio nacional, Brasil
PAS - Polish Academy of Sciences
RAS - Russian Academy of Sciences
RMIB - Royal Meteorological Institute of Belgium
ROA - Real Instituto y Observatorio de la Armada
SAS - Slovak Academy of Sciences
SBG - Seismological Bureau of Guangdong
SGU - Geological Survey of Sweden
UBRAS - Ural Branch of Russian Academy of Sciences
UMUN - University of Munich
UNLP - Universidad Nacional de La Plata, Argentina
USGS - United States Geological Survey
VAST - Vietnam Academy of Science and Technology
VNCST - Vietnam National Center for Science and Technology

APPENDIX B-2

PICTORIAL MAP - SATELLITE FOOTPRINTS AND IMOs OPERATING IN 2012



APPENDIX C-1

IAFV2.10 INTERMAGNET ARCHIVE FORMAT
BINARY DATA STRUCTURE FORMAT-32 BIT WORDS

	Word		
HEADER	1	-Station ID	eg: BOU = HEX(20 42 4F 55)
		-Year||Day Num	eg: 1989001; year 1989, day January 01
		-Co-Latitude	(90° - Latitude) * 1000
		-Longitude	East Longitude * 1000
		-Elevation	elevation in meters above sea level
		-Orientation	eg: XYZG = HEX(58 59 5A 47) (or HDZG, XYZ, HDZ)
		-Source	eg: DMI = HEX(20 44 4D 49)
		-D conversion	H/3438*10000 where H=annual mean of H (set to 10000 for XYZG)
		-Data Quality	IMAG = HEX (49 4D 41 47)
		-Instrumentation	eg: LC(Linear Core) = HEX(20 20 4C 43) (or RC(Ring Core))
		-K9 value in nT	eg: 750
		-Sampling rate (ms)	eg: 125
		-Sensor orientation	eg: XYZF, DIF, UVZ, HDZ, HDZF etc.
		-Publication Date	eg: YYMM = 0806 (June 2008) HEX (30 38 30 36)
		-IAF version number	HEX(03 00 00 00)version 2.10
	16	-Reserved for future use	
ONE MINUTE DATA	17	-1440 mean minute values - element 1 (one day).	Missing value = 999999
	.....	-1440 mean minute values - element 2 (one day).	Missing value = 999999
	.....	-1440 mean minute values - element 3 (one day).	Missing value = 999999
	 5776	-1440 mean minute values - element 4 (one day).	Missing value = 999999 Scalar not recorded = 888888
MEAN HOURLY DATA	5777	-24 mean hourly values - element 1.	Missing value = 999999
	.....	-24 mean hourly values - element 2.	Missing value = 999999
	.....	-24 mean hourly values - element 3.	Missing value = 999999
	 5872	-24 mean hourly values - element 4.	Missing value = 999999
DAILY MEANS	5873	-daily mean value element 1.	Missing value = 999999
		-daily mean value element 2.	Missing value = 999999
		-daily mean value element 3.	Missing value = 999999
	5876	-daily mean value element 4.	Missing value = 999999
K INDICES	5877	-8 K-values.	Missing value = 999
		-	
		-	
		-	
		-	
		-	
		-	
		-	
	5888	RESERVED FOR EACH CONTRIBUTING INSTITUTION	

See sections 4.3 and 4.3.1 for details

APPENDIX C-1 (Cont'd)

IAFV2.00 INTERMAGNET ARCHIVE FORMAT
BINARY DATA STRUCTURE FORMAT-32 BIT WORDS

	WORD		
HEADER	1	-Station ID	eg: BOU = HEX(20 42 4F 55)
		-Year||Day Num	eg: 1989001; year 1989, day January 01
		-Co-Latitude	(90° - Latitude) * 1000
		-Longitude	East Longitude * 1000
		-Elevation	elevation in meters above sea level
		-Orientation	eg: XYZG = HEX(58 59 5A 47) (or HDZG)
		-Source	eg: DMI = HEX(20 44 4D 49)
		-D conversion	H/3438*10000 where H=annual mean of H (set to 10000 for XYZG)
		-Data Quality	IMAG = HEX (49 4D 41 47)
		-Instrumentation	eg: LC(Linear Core) = HEX(20 20 4C 43) (or RC(Ring Core))
		-K9 value in nT	eg: 750
		-Sampling rate (ms)	eg: 125
		-Sensor orientation	eg: XYZF, DIF, UVZ, HDZ, HDZF etc.
		-Publication Date	eg: YYMM = 0806 (June 2008) HEX (30 38 30 36)
		-IAF version number	HEX(02 00 00 00)version 2.00
	16	-Reserved for future use	

	WORD	
ONE MINUTE DATA	17	-1440 mean minute values - element 1 (one day). Missing value = 999999
	.....	-1440 mean minute values - element 2 (one day). Missing value = 999999
	.....	-1440 mean minute values - element 3 (one day). Missing value = 999999
	 5776	-1440 mean minute values - element 4 (one day). Missing value = 999999
MEAN HOURLY DATA	5777	-24 mean hourly values - element 1. Missing value = 999999
	.....	-24 mean hourly values - element 2. Missing value = 999999
	.....	-24 mean hourly values - element 3. Missing value = 999999
	 5872	-24 mean hourly values - element 4. Missing value = 999999
DAILY MEANS	5873	-daily mean value element 1. Missing value = 999999
		-daily mean value element 2. Missing value = 999999
		-daily mean value element 3. Missing value = 999999
	5876	-daily mean value element 4. Missing value = 999999
K INDICES	5877	-8 K-values. Missing value = 999
		-
		-
		-
		-
		-
		-
		-
	5888	RESERVED FOR EACH CONTRIBUTING INSTITUTION

See sections 4.3 and 4.3.2 for details

IAFV1.10 INTERMAGNET ARCHIVE FORMAT
BINARY DATA STRUCTURE FORMAT-32 BIT WORDS

	WORD		
HEADER	1	-Station ID	eg: BOU = HEX(20 42 4F 55)
		-Year||Day Num	eg: 1989001; year 1989, day January 01
		-Co-Latitude	(90° - Latitude) * 1000
		-Longitude	East Longitude * 1000
		-Elevation	elevation in meters above sea level
		-Orientation	eg: XYZF = HEX(58 59 5A 46) (or HDZF)
		-Source	eg: DMI = HEX(20 44 4D 49)
		-D conversion	H/3438*10000 where H=annual mean of H (set to 10000 for XYZF)
		-Data Quality	IMAG = HEX (49 4D 41 47)
		-Instrumentation	eg: LC(Linear Core) = HEX(20 20 4C 43) (or RC(Ring Core))
		-K9 value in nT	eg: 750
		-Sampling rate (ms)	eg: 125
		-Sensor orientation	eg: XYZF, DIF, UVZ, HDZ, HDZF etc.
		-Publication Date	eg: YYMM = 0806 (June 2008) HEX (30 38 30 36)
		-IAF version number	HEX(01 00 00 00)IAFV1.10
	16	-Reserved for future use	
ONE MINUTE DATA	17	-1440 mean minute values - element 1 (one day).	Missing value = 999999
	.....	-1440 mean minute values - element 2 (one day).	Missing value = 999999
	.....	-1440 mean minute values - element 3 (one day).	Missing value = 999999
	5776	-1440 mean minute values - element 4 (one day).	Missing value = 999999
MEAN HOURLY DATA	5777	-24 mean hourly values - element 1.	Missing value = 999999
	.....	-24 mean hourly values - element 2.	Missing value = 999999
	.....	-24 mean hourly values - element 3.	Missing value = 999999
	5872	-24 mean hourly values - element 4.	Missing value = 999999
DAILY MEANS	5873	-daily mean value element 1.	Missing value = 999999
		-daily mean value element 2.	Missing value = 999999
		-daily mean value element 3.	Missing value = 999999
	5876	-daily mean value element 4.	Missing value = 999999
K INDICES	5877	-8 digitally derived K-values.	Missing value = 999
		-	
		-	
		-	
		-	
		-	
		-	
		-	
	5888	RESERVED FOR FUTURE USE = 0	

See sections 4.3 and 4.3.3 for details

IAFV1.00 INTERMAGNET ARCHIVE FORMAT
BINARY DATA STRUCTURE FORMAT-32 BIT WORDS

	WORD		
HEADER	1	-Station ID	eg: BOU = HEX(20 42 4F 55)
		-Year||Day Num	eg: 1989001; year 1989, day January 01
		-Co-Latitude	(90° - Latitude) * 1000
		-Longitude	East Longitude * 1000
		-Elevation	elevation in meters above sea level
		-Orientation	eg: XYZF = HEX(58 59 5A 46) (or HDZF)
		-Source	eg: DMI = HEX(20 44 4D 49)
		-D conversion	H/3438*10000 where H=annual mean of H
		-Data Quality	IMAG = HEX (49 4D 41 47)
		-Instrumentation	eg: LC(Linear Core) = HEX(20 20 4C 43) (or RC(Ring Core))
		-K9 value in nT	eg: 750
		-Sampling rate (ms)	eg: 125
		-Sensor orientation	eg: XYZF, DIF, UVZ, HDZ, HDZF etc.
		-Reserved for future use = 0	
		-IAF version number	HEX(00 00 00 00)IAFV1.00
	16	-Reserved for each contributing institution	
ONE MINUTE DATA	17	-1440 mean minute values - element 1 (one day). Missing value = 999999	
		-1440 mean minute values - element 2 (one day). Missing value = 999999	
		-1440 mean minute values - element 3 (one day). Missing value = 999999	
	5776	-1440 mean minute values - element 4 (one day). Missing value = 999999	
MEAN HOURLY DATA	5777	-24 mean hourly values - element 1. Missing value = 999999	
		-24 mean hourly values - element 2. Missing value = 999999	
		-24 mean hourly values - element 3. Missing value = 999999	
	5872	-24 mean hourly values - element 4. Missing value = 999999	
DAILY MEANS	5873	-daily mean value element 1. Missing value = 999999	
		-daily mean value element 2. Missing value = 999999	
		-daily mean value element 3. Missing value = 999999	
	5876	-daily mean value element 4. Missing value = 999999	
K INDICES	5877	-8 digitally derived K-values. Missing value = 999	
		-	
		-	
		-	
		-	
		-	
		-	
		-	
		-see section 4.3.3 for details on word 5885	
	5888	RESERVED FOR FUTURE USE = 0	

See sections 4.3 and 4.3.4 for details

APPENDIX C-2

INTERMAGNET DVD/CD-ROM DIRECTORY STRUCTURE

```
ROOT DIRECTORY
   │     │
   │     │
   │  README.EXE
   │  README.TXT
   │
   ├───MAG1991
   │     ├───1991MAPS
   │     │       ALL.PCX
   │     │       AUS.PCX
   │     │          :
   │     │          :
   │     │
   │     ├───CTRY_INF
   │     │       CTRYLIST.IDX
   │     │
   │     │       ALLSRN.PCX
   │     │       AUSSRN.PCX
   │     │       CANSRN.PCX
   │     │            :
   │     │            :
   │     │
   │     │       README.ALL
   │     │       README.AUS
   │     │            :
   │     │            :
   │     │
   │     │
   │     ├───AMS
   │     │       AMS91APR.BIN
   │     │       AMS91AUG.BIN
   │     │            :
   │     │            :
   │     │       README.AMS
   │     │       AMS91K.DKA
   │     │
   │     ├───BFE
   │     │       BFE91APR.BIN
   │     │       BFE91AUG.BIN
   │     │            :
   │     │            :
   │     │       README.BFE
   │     │       BFE91K.DKA
   │     │
   │     ├───BLC
   │     │    :
   │     │    :
   │     ├───VIC
   │     │
   │     └───OBSY_INF
   │           91OBSDAT.DBF
   └───XTRAS
       PRNSTRUC.EXE
       STRUCTUR.DAT
```

APPENDIX C-3

IYFV1.02 INTERMAGNET DVD/CD-ROM FORMAT FOR YEARMEAN FILE

Magnetic data with 1nT or 0.1min of arc resolution are organized on a year file basis. One file contains all annual mean values of the geomagnetic field components that are available from the observatory.

File name: "YEARMEAN" and the three-letter observatory ID code as an extension. eg: YEARMEAN.BOU for Boulder.

Each file may have from 1 to 3 tables containing annual mean values. The file must contain a table of annual means for ALL-DAYS, but may also contain tables of annual means for QUIET-DAYS and DISTURBED-DAYS.

Description of the header block

The header contains information on observatory name, ID-code, Colatitude, Longitude and Elevation. It further contains the headers for each data columns.
eg: The header for Wingst is:

```
                    ANNUAL MEAN VALUES

                   WINGST WNG, GERMANY

 COLATITUDE:  36.257   LONGITUDE:  9.073 E    ELEVATION: 50 m

  YEAR        D          I          H      X      Y      Z      F  *  ELE   Note

             deg  min deg  min    nT     nT     nT     nT     nT
```

Description of data space (75 characters per line including CrLf)

All data fields are right-justified. The field width must be maintained, either by zero-filling or space-filling. The '+'sign for positive values is optional.

_YYYY.yyy_DDD_dd.d_III_ii.i_HHHHHH_XXXXXX_YYYYYY_ZZZZZZ_FFFFFF_A_EEEE_NNNCrLf
....
....

YYYY.yyy	: Epoch is given with 3 decimals.
DDD_dd.d	: Declination is given in degrees and decimal minutes of arc.
III_ii.i	: Inclination is given in degrees and decimal minutes of arc.
HHHHHH	: H-component is given in nT.
XXXXXX	: X-component is given in nT.
YYYYYY	: Y-component is given in nT.
ZZZZZZ	: Z-component is given in nT.
FFFFFF	: F-component is given in nT.
A	: Type of annual means. May be "A"ll, "Q"uiet, "D"isturbed, "I"ncomplete" or "J"ump. The "J" is not an annual mean value, but indicates a jump in the observatory recordings, which should be described in a note.
EEEE	: recorded elements. eg:"XYZF" or "HDZF".
NNN	: Note number.
CrLf	: Indicates a Carriage return Line feed.

- Missing angular values must be coded as three 9 digits, a space, two 9 digits, a dot and one 9 digit: 999 99.9
- Missing component values must be coded as six 9 digits: 999999
- Angular values are written as degrees and minutes. Values may be written in the range 0 to 360 or -180 to 180. Observatories may choose which range to use. Negative values must always have the minus sign before the degree field, never before the minute field (including values between 0 and -1 degrees, for example "-0 59" means a value of minus zero degrees fifty nine minutes). This applies to all types of records, including jump records.

IYFV1.02 INTERMAGNET DVD/CD-ROM FORMAT FOR YEARMEAN FILE

Description of the footer

At the end of the file is added a footer describing the data. The footer contains notes on jumps , incomplete data sets etc. A sample footer looks like this:

* A = All days
* Q = Quiet Days
* D = Disturbed Days
* I = Incomplete
* J = Jump: jump value = old site value - new site value

ELE = Recorded elements from which the annual means were derived. If an independent total field measurement is not made at an observatory, this field should not include an 'F' code. For example, an observatory using a three component fluxgate with one horizontal sensor aligned along the magnetic meridian and a proton magnetometer would put 'HDZF' in this field. An observatory using only the fluxgate would put 'HDZ'.

Notes:1. The jump in the values from 1988 to 1989 is due to establishment of a new absolute pillar during 1988.
2. The jump in the values from 1993 to 1994 is due to a change in the difference delta-F between the PPM pillar and the absolute pillar. The change happened between spring 1989 and autumn 1993. Why and when is unknown.

Sample of a yearmean file

```
                          ANNUAL MEAN VALUES

                      NARSARSUAQ, NAQ, GREENLAND

 COLATITUDE:  28.84       LONGITUDE: 314.56 E       ELEVATION:  4 meters

   YEAR       D         I         H      X      Y      Z      F  * ELE Note
          Deg.  '   Deg.  '      nT     nT     nT     nT     nT

1983.500 326 41.6  77 15.8  12152  10156  -6673  53764  55120 A  DHZ
1984.500 326 55.7  77 14.3  12171  10199  -6642  53736  55097 A  DHZ
1985.500 327 11.1  77 12.9  12187  10242  -6604  53706  55071 A  DHZ
1986.500 327 26.8  77 11.7  12201  10284  -6565  53679  55048 A  DHZ
1987.500 327 44.5  77 09.9  12223  10336  -6524  53647  55022 A  DHZ
1988.500 328 00.5  77 09.0  12235  10377  -6482  53633  55011 A  DHZ
1989.000   0 02.6   0 00.7     -4      2     10     30     28 J  DHZ   1
1989.500 328 13.8  77 07.2  12254  10418  -6452  53592  54975 A  DHZ
1990.500 328 29.9  77 05.9  12271  10463  -6412  53571  54959 A  DHZ
1991.500 328 45.6  77 04.9  12284  10503  -6371  53555  54946 A  DHZ
1992.500 329 01.3  77 03.4  12302  10547  -6332  53525  54920 A  DHZ
1993.500 329 17.9  77 01.6  12323  10596  -6292  53495  54896 A  DHZ
1994.000   0 00.0   0 00.0     -1     -1      0     -2     -3 J  DHZ   2
1994.500 329 34.3  77 00.7  12335  10636  -6247  53476  54880 A  DHZ
1995.500 329 53.6  76 58.3  12366  10698  -6203  53444  54856 A  DHZ
1996.500 330 13.6  76 56.0  12395  10759  -6155  53409  54828 A  DHZ
1997.500 330 33.9  76 54.0  12423  10819  -6105  53381  54807 A  DHZ
1998.500 330 55.6  76 52.2  12446  10878  -6048  53361  54793 A  DHZ
1999.500 331 17.3  76 50.2  12473  10939  -5992  53332  54771 A  DHZ
2000.500 331 39.0  76 48.4  12497  10998  -5934  53311  54756 A  DHZ
2001.500 332 01.3  76 46.1  12527  11063  -5877  53278  54731 A  DHZ
2002.500 332 23.6  76 44.2  12553  11124  -5817  53254  54714 A  DHZ
2003.500 332 45.2  76 43.3  12564  11170  -5752  53237  54699 A  DHZ
2004.500 333 07.8  76 40.5  12600  11240  -5695  53202  54674 A  DHZ
2005.500 333 29.3  76 38.7  12624  11296  -5635  53176  54654 A  DHZ
```

1983.500	326 42.3	77 15.1	12164	10167	-6677	53765	55124	Q	DHZ	
1984.500	326 56.3	77 13.3	12186	10213	-6648	53734	55098	Q	DHZ	
1985.500	327 11.6	77 12.0	12202	10256	-6611	53704	55073	Q	DHZ	
1986.500	327 27.4	77 10.8	12215	10297	-6571	53676	55048	Q	DHZ	
1987.500	327 44.9	77 09.4	12232	10345	-6527	53648	55025	Q	DHZ	
1988.500	328 00.8	77 08.2	12246	10387	-6487	53631	55011	Q	DHZ	
1989.000	0 02.6	0 00.7	-4	2	10	30	28	J	DHZ	1
1989.500	328 14.4	77 06.6	12263	10427	-6455	53591	54976	Q	DHZ	
1990.500	328 30.0	77 05.3	12279	10470	-6416	53567	54956	Q	DHZ	
1991.500	328 46.1	77 04.0	12297	10515	-6376	53551	54945	Q	DHZ	
1992.500	329 01.6	77 02.7	12312	10556	-6336	53521	54919	Q	DHZ	
1993.500	329 18.2	77 00.9	12335	10607	-6297	53491	54895	Q	DHZ	
1994.000	0 00.0	0 00.0	-1	-1	0	-2	-3	J	DHZ	2
1994.500	329 35.4	76 59.2	12357	10657	-6255	53470	54879	Q	DHZ	
1995.500	329 54.2	76 57.5	12380	10711	-6208	53443	54858	Q	DHZ	
1996.500	330 13.6	76 55.5	12403	10766	-6159	53407	54828	Q	DHZ	
1997.500	330 34.2	76 53.4	12431	10827	-6108	53380	54808	Q	DHZ	
1998.500	330 55.5	76 51.6	12456	10886	-6053	53359	54793	Q	DHZ	
1999.500	331 17.9	76 49.6	12483	10949	-5995	53330	54771	Q	DHZ	
2000.500	331 39.3	76 47.8	12507	11007	-5938	53308	54755	Q	DHZ	
2001.500	332 01.5	76 45.6	12535	11070	-5880	53278	54733	Q	DHZ	
2002.500	332 23.7	76 43.6	12562	11132	-5821	53252	54714	Q	DHZ	
2003.500	332 45.9	76 42.0	12584	11189	-5759	53234	54701	Q	DHZ	
2004.500	333 08.1	76 39.7	12613	11252	-5700	53200	54675	Q	DHZ	
2005.500	333 29.6	76 37.8	12640	11311	-5641	53177	54659	Q	DHZ	

1983.500	326 40.4	77 17.7	12121	10128	-6659	53763	55112	D	DHZ	
1984.500	326 54.6	77 16.5	12136	10168	-6626	53744	55097	D	DHZ	
1985.500	327 10.1	77 14.7	12158	10216	-6592	53707	55066	D	DHZ	
1986.500	327 25.6	77 13.7	12169	10255	-6552	53683	55045	D	DHZ	
1987.500	327 43.9	77 11.0	12205	10320	-6516	53645	55016	D	DHZ	
1988.500	327 59.5	77 10.9	12204	10349	-6469	53636	55007	D	DHZ	
1989.000	0 02.6	0 00.7	-4	2	10	30	28	J	DHZ	1
1989.500	328 12.2	77 08.9	12228	10393	-6443	53598	54975	D	DHZ	
1990.500	328 30.0	77 07.3	12249	10444	-6400	53577	54959	D	DHZ	
1991.500	328 45.1	77 06.5	12258	10480	-6359	53560	54945	D	DHZ	
1992.500	329 00.8	77 05.6	12268	10517	-6316	53539	54927	D	DHZ	
1993.500	329 16.8	77 03.5	12295	10570	-6281	53502	54897	D	DHZ	
1994.000	0 00.0	00 00.0	-1	-1	0	-2	-3	J	DHZ	2
1994.500	329 33.2	77 02.9	12300	10604	-6233	53481	54877	D	DHZ	
1995.500	329 52.6	76 59.7	12344	10677	-6195	53445	54852	D	DHZ	
1996.500	330 12.9	76 57.1	12378	10743	-6149	53411	54827	D	DHZ	
1997.500	330 33.7	76 54.8	12409	10807	-6099	53382	54805	D	DHZ	
1998.500	330 54.7	76 54.2	12416	10850	-6036	53371	54796	D	DHZ	
1999.500	331 17.0	76 51.9	12446	10915	-5980	53336	54769	D	DHZ	
2000.500	331 37.8	76 50.1	12472	10974	-5926	53317	54756	D	DHZ	
2001.500	332 00.3	76 47.0	12512	11048	-5873	53276	54726	D	DHZ	
2002.500	332 23.3	76 45.3	12536	11108	-5810	53256	54711	D	DHZ	
2003.500	332 44.1	76 45.7	12526	11134	-5738	53245	54698	D	DHZ	
2004.500	333 06.5	76 42.6	12567	11208	-5684	53206	54670	D	DHZ	
2005.500	333 29.1	76 40.1	12600	11275	-5625	53174	54647	D	DHZ	

* A = All Days
* Q = Quiet Days
* D = Disturbed Days
* J = Jumps   jump value = old site value - new site value

ELE = Recorded elements from which the annual mean values were derived

Notes:
1. The jump in the values from 1988 to 1989 is due to establishment of a new absolute pillar during 1988.
2. The jump in the values from 1993 to 1994 is due to a change in the difference delta-F between the PPM pillar and the absolute pillar. The change happened between spring 1989 and autumn 1993. Why and when is unknown.

Sample of missing values

YEAR	D Deg. '	I Deg. '	H nT	X nT	Y nT	Z nT	F nT	*	ELE	Note
1983.500	999 99.9	999 99.9	999999	999999	999999	999999	999999	A	DHZ	
1984.500	999 99.9	77 14.3	12171	999999	-6642	53736	55097	A	DHZ	

APPENDIX D-1

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APPENDIX E-1

INTERMAGNET FORMAT IMFV2.83

The INTERMAGNET satellite data transmission format IMFV2.83 defines the structure of 126 bytes of magnetic observatory information. METEOSAT users, who must transmit once per hour, will send five 12-minute IMFV2.83 data blocks. GOES users transmit at 12-minute intervals one IMFV2.83 data block encoded in NESS-BINARY (189 bytes). The order of transmission to the satellite will be in byte sequence low-byte first, then high-byte. Refer to Appendix E-2 for satellite coding examples.

HEADER 12 BYTES		
Time stamp of the first sample		Byte #
Day (1-365/366)	12 Bits	1 - 3 *
Minute of the day (0 - 1439)	12 Bits	1 - 3 *
Offset for C1	8 Bits	4
Offset for C2	8 Bits	5
Offset for C3	8 Bits	6
Offset for C4	8 Bits	7
Flags #1	8 Bits	8
Flags #2	8 Bits	9
Identification:		
Colatitude in 1/10 degrees (0 - 1800)	12 Bits	10 - 12 *
East Longitude in 1/10 degrees (0 - 3600)	12 Bits	10 - 12 *
FREE SPACE 8 BYTES		
REFERENCE MEASUREMENT (RM) SPACE OR FREE SPACE 10 BYTES		
MINUTE VALUES 96 BYTES		
C1 for sample 1	16 Bits	31-32
C2 for sample 1	16 Bits	33-34
C3 for sample 1	16 Bits	35-36
.	.	.
.	.	.
.	.	.
C1 for sample 12	16 Bits	119-120
C2 for sample 12	16 Bits	121-122
C3 for sample 12	16 Bits	123-124
C4 for sample 12	16 Bits	125-126

* See Header Encoding

FLAGS #1

MSB (8) & (7) Orientation code 0: X,Y,Z
1: H,D,Z
2: D,I,F
3: Other

Orientation Code	Component 1	Component 2	Component 3	Component 4
0	X	Y	Z	F
1	H	D	Z	F
2		D	I	F
3	.	. (OTHER)	.	.

(6) Scale factor for X or H
(5) Scale factor for Y or D
(4) Scale factor for Z or I
(3) Scale factor for F
(2) Filtering 0: INTERMAGNET approved filtering
1: non-approved filtering
See INTERMAGNET terminology "filtering"
(1) Alert capability -- The IMO has the ability to detect magnetic events
if the flag is set to 1.
0: not active
1: active

MSB LSB

Orientation	Code	Scale factor	Scale factor	Scale factor	Scale factor	Filter	Alert Capability
8	7	6	5	4	3	2	1

FLAGS #2

MSB (8) Sudden storm commencement detected
(7) Storm in progress -- A storm is in progress if the level of magnetic activity is equivalent to K>4 for past one-hour period. The flag will be reset to zero when the equivalent level of activity drops to K<4.
(6) 0: No Reference Measurement (RM) capability bytes 13-30 are user free space
1: Base Reference Measurement data available in bytes 21-30. Bytes' 13-20 are user free space.
(5) (4) (3) (2) (1) Free (user defined)

MSB LSB

SSC	SIP	R M	Reserved	Free for user	Free for user	Free for user	Free for user
8	7	6	5	4	3	2	1

APPENDIX E-1 (Cont'd)

IMFV2.83 HEADER ENCODING

In IMFV2.83 format, the time stamp and site identification code are encoded in 3-byte strings formed from two 12-bit fields combined as described below:

```
Time Stamp Input                            Encoded Output
Least sig. 8 bits of day                    Byte 1
Most sig. 4 bits of day                     Byte 2, four least sig. bits
Least sig. 4 bits of minute                 Byte 2, four most sig. bits
Most sig. 8 bits of minute                  Byte 3

Site Identification Code Input              Encoded Output
Least sig. 8 bits of colatitude             Byte 10
Most sig. 4 bits of colatitude              Byte 11, four least sig. bits
Least sig. 4 bits of east longitude         Byte 11, four most sig. bits
Most sig. 8 bits of east longitude          Byte 12

Example:
     The time stamp for day 30, minute 684 would be encoded as:

Input fields
     msb                              lsb
     11 10  9  8  7  6  5  4  3  2  1  0

      0  0  0  0  0  0  0  1  1  1  1  0   Day    30   0 1 E (first item)
      0  0  1  0  1  0  1  0  1  1  0  0   Minute 684  2 A C (second item)

Output Encoded field
                     Byte 0            Byte 1              Byte 2

                    0001 1110         1100 0000           0010 1001
HEX                   1    E            C    0              2    A
                    8 lsb Day         4 lsb Minute        8 msb Minute
                                      4 msb Day

The encoded 3 bytes output from this example would be 1ECO2A.
```

IMFV2.83 DATA VALUE ENCODING

Constraints on the bandwidth of a GOES satellite communications channel dictate a maximum transmission block of 126 bytes of data once every 12 minutes from an INTERMAGNET Magnetic Observatory (IMO). To conserve bytes, each measurement of a magnetic component is represented using only 2 bytes which, upon reception, are interpreted together with header information to produce a resultant 3-byte representation at the Geomagnetic Information Node (GIN). All magnetic field values in this encoding description are expressed in tenths of nanoTeslas (tnT) unless otherwise noted. The resolution of the measurements is 1 tnT and so a 16-bit representation allows a 2^{16} = 65536 tnT (6553.6 nT) dynamic range within a 12-minute IMFV2.83 block. This is inadequate to accomodate magnetic storms at some locations, and so the encoding scheme produces measurements at reduced sensitivity when extremely large excursions are present. The INTERMAGNET data encoding produces an Offset (OFF) value and a Scale Factor (SF) flag bit for each component, as well as the encoded individual minute values (see diagram at end of appendix). The OFF and SF apply to all measurements of a component within an IMFV2.83 data block.

We define the terms used in encoding as follows:

Data(i)	Set of minute values measured in tnT
$D_{pos}(i)$	Minute values shifted by 1048576 to be always positive
D_{max}	Largest $D_{pos}(i)$ of a given component in IMFV2.83 block
D_{min}	Smallest $D_{pos}(i)$ of a given component in IMFV2.83 block
OFF	Offset value
BF	Bias Factor = 8192
SM	Scale Multiplier for sensitivity of encoded data
SF	Scale Factor flag for sensivity of encoded data
E(i)	Set of encoded minute values

Numbers used in this encoding algorithm have been chosen to permit simple binary arithmetic operations:

$8192 = 2^{13}$
$57344 = 2^{16} - 2^{13}$
$1048576 = 2^{20}$
$2097151 = 2^{21} - 1$

Encoding of a 12-minute IMFV2.83 data block begins by adding a constant 1048576 tnT to the minute values Data(i) to produce a new data set $D_{pos}(i)$ whose values are always positive.

$$D_{pos}(i) = Data(i) + 1048576 \qquad (1)$$

The limiting values of these $D_{pos}(i)$ are 0 and 2097151 tnT.

An Offset value (OFF) is next computed from the $D_{pos}(i)$ for each component by using the minimum value of the component, D_{min}.

$$OFF = INT\ (D_{min}/BF) \qquad (2)$$

where INT means the truncated integer after the division. The OFF value for each component may be anywhere in the range of 0 to 255 and the OFF values for the four components are stored in bytes 4,5,6,7 of the header for use in decoding the data after reception at a GIN.

A Scale Multiplier (SM) for each component is now computed:

$$SM = INT\ ((D_{max} - OFF*BF)/57344) + 1 \qquad (3)$$

The encoding algorithm produces an SM whose value is governed by the range of $D_{pos}(i)$ within a data block. In this application to format IMFV2.83, however, SM can in practice be limited to values of either 1 or 2. Format IMFV2.83 reserves only one flag bit per component for storing scale information. These flags are bits 6,5,4,3 of byte 8 in the header, labelled Scale Factor (SF). Flag bit SF=0 represents SM=1, where the encoded data are considered at normal sensitivity (1 tnT/bit). At SM=1, the dynamic range available in the data block is at least 49152 tnT (= 57344-BF) and at most 57344 tnT, depending upon where the D_{min} value sits relative to the quantity OFF*BF. Flag bit SF=1 represents SM=2, where the encoded data are considered as half sensitivity (2 tnT/bit). At SM=2, the dynamic range in the data block is at least 106496 tnT (= 2*57344-BF) and at most 114688 tnT (= 2*57344) depending again upon where D_{min} is relative to the quantity OFF*BF.

Encoded data values are now computed as:

$$E(i) = INT((D_{pos}(i) - OFF*BF)/SM) \qquad (4)$$

and are stored in bytes 31 to 126. Upon reception at the GIN, encoded data are reconstituted using the expression:

$$Data(i) = E(i)*SM + OFF*BF - 1048576 \qquad (5)$$

This reconstitution is exact for SM=1 but rounded down by no more than 2 tnT on those infrequent occasions when SM=2.

In summary, the expressions defining each of the encoding and reconstitution steps are:

$$D_{pos}(i) = Data(i) + 1048576 \qquad (1)$$
$$OFF = INT\ (D_{min}/BF) \quad (BF=8192) \qquad (2)$$
$$SM = INT\ ((D_{max} - OFF*BF)/57344) + 1 \qquad (3)$$
$$E(i) = INT((D_{pos}(i) - OFF*BF)/SM) \qquad (4)$$
$$Data(i) = E(i)*SM + OFF*BF - 1048576 \qquad (5)$$

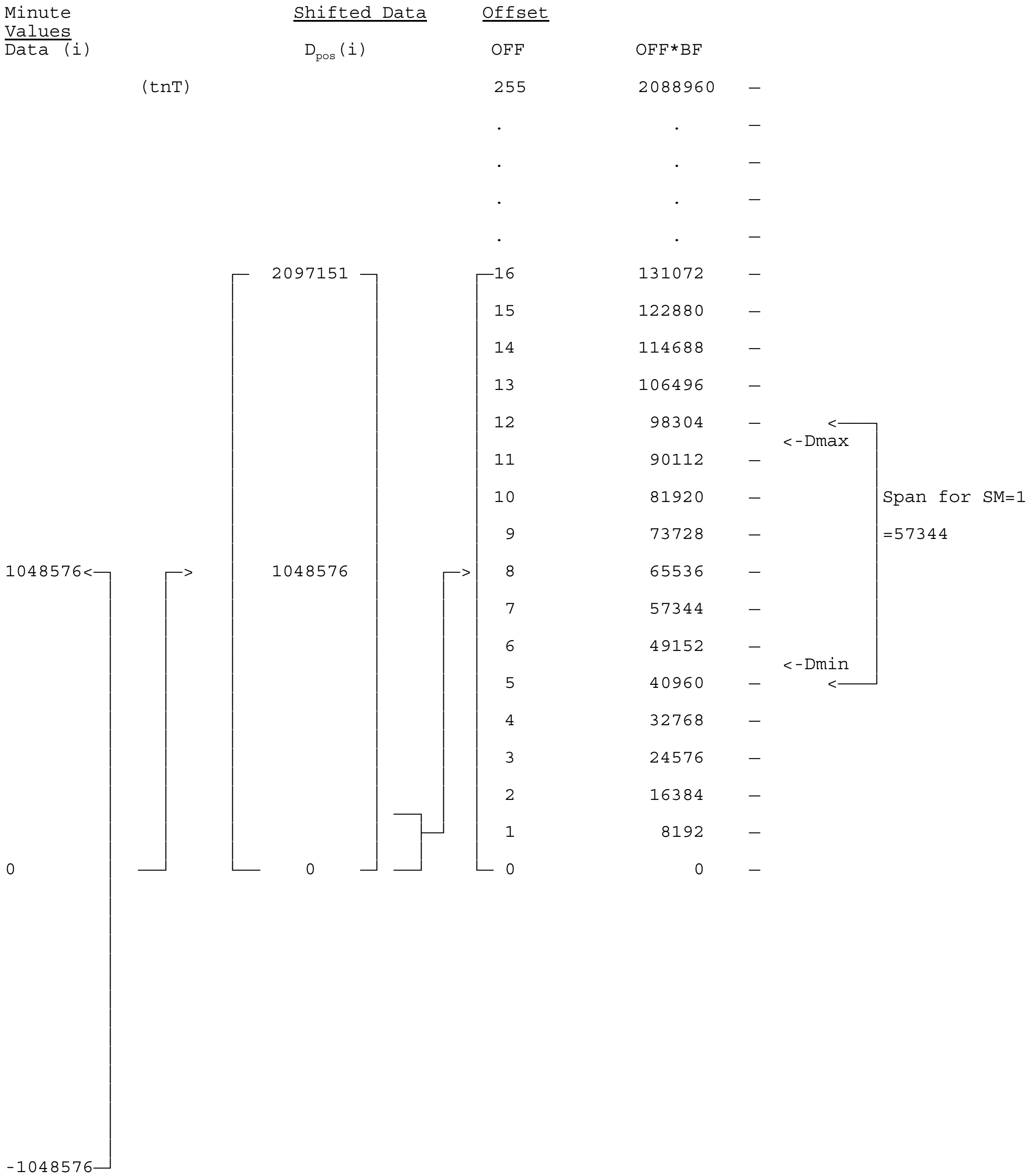
Scale Factor flags are set as follows:

SF	SM
0	1
1	2

NOTE: E(i) set to 65535 (FFFF hex) indicates missing or invalid data.

APPENDIX E-1 (Cont'd)

IMFV2.83 DATA VALUE ENCODING



APPENDIX E-2

SATELLITE CODING EXAMPLES

CODING EXAMPLE FOR GOES SATELLITE

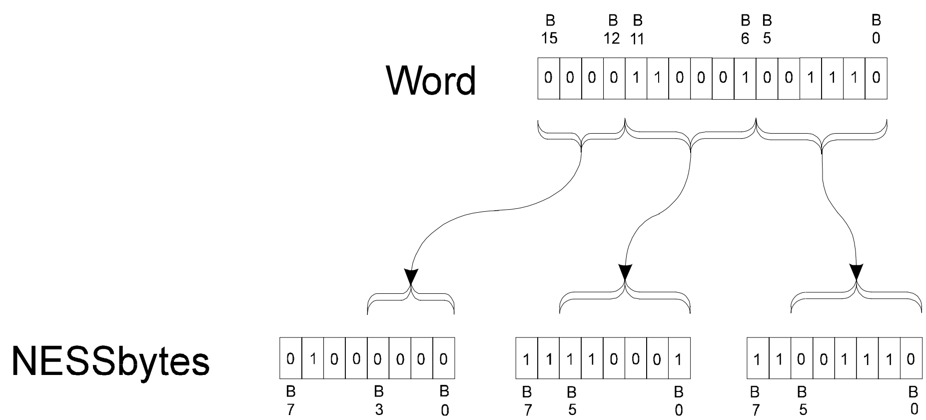
Each block of 126 bytes in IMFV2.83 must be encoded in 189 NESS-BINARY bytes (NESSbytes). NESS-BINARY breaks each pair of source bytes (word) into 3 NESSbytes. If the bits of the source word are B15-B0 with B15 the most significant, then these are placed right-justified in NESSbytes as follows: B15-B12 are in the first NESSbyte, B11-B6 are in the second NESSbyte and B5-B0 are in the third NESSbyte. Within NESSbytes, bit 6 is always set to 1 and bit 7 is set for odd parity. In the first NESSbyte, bits 5 and 4 are filled by sign extension, i.e. they take the same value as bit 3. As an example, consider the 16-bit source word h0C4E, d3150.

Step 1 - break into 3 formative NESSbytes.

byte 1: XXXX0000
byte 2: XX110001
byte 3: XX001110

Step 2 - sign extend in byte 1, bit 6=1, bit 7=odd parity.

NESSbyte 1:01000000
NESSbyte 2:11110001
NESSbyte 3:11001110



After encoding, the 12-minute block is sent to the data collection platform (DCP) to be transmitted.

Consider the following data set:

Date: March 23 1993 (day 082)
Time of first sample 12:00
Observatory identification: 04342275 (co-latitude 43.4°, longitude 227.5°)
Sensor orientation is XYZF
INTERMAGNET approved filtering
No alert capability
No RMs
Flag #1: 00000000
Flag #2: 00000000

Minute values of C1, C2, C3, C4

209062 -56 423216 472036
209062 -52 423218 472038
209058 -46 423220 472038
209053 -49 423219 472035
209052 -51 423214 472030
209054 -55 423214 472031
209061 -56 423215 472035
209066 -55 423217 472039
209062 -52 423214 472034
209055 -54 423212 472030
209055 -52 423213 472030
209056 -50 423213 472031

Hex dump of IMFV2.83 binary of this 12-minute block: (126 characters)

```
52  00  2D  99  7F  B3  B9  00  00  B2  31  8E  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00
00  A6  10  C8  1F  30  15  E4  13  A6  10  CC  1F  32  15  E6  13  A2  10  D2  1F  34  15  E6  13  9D  10  CF  1F
33  15  E3  13  9C  10  CD  1F  2E  15  DE  13  9E  10  C9  1F  2E  15  DF  13  A5  10  C8  1F  2F  15  E3  13  AA
10  C9  1F  31  15  E7  13  A6  10  CC  1F  2E  15  E2  13  9F  10  CA  1F  2C  15  DE  13  9F  10  CC  1F  2D  15
DE  13  A0  10  CE  1F  2D  15  DF  13
```

After conversion to NESS-BINARY for GOES satellite: (189 characters)

```
45  C8  40  C2  76  D9  C7  FE  73  FB  64  40  40  C2  F2  43  46  CE  40  40  40  40  40  40  40  40  40  40  40
40  40  40  40  40  40  40  40  40  40  40  40  40  40  40  40  7A  58  D0  7C  E0  DF  43  40  D5  FE  D0  D3  7A
58  D0  7C  70  DF  43  C8  D5  FE  58  D3  7A  C8  D0  FD  C8  DF  43  D0  D5  FE  58  D3  79  F4  D0  7C  7C  DF
43  4C  D5  FE  4C  D3  79  70  D0  7C  F4  DF  C2  F8  D5  FD  F8  D3  79  F8  D0  7C  64  DF  C2  F8  D5  FD  7C
D3  7A  54  D0  7C  E0  DF  C2  7C  D5  FE  4C  D3  7A  68  D0  7C  64  DF  43  C4  D5  FE  DC  D3  7A  58  D0  7C
70  DF  C2  F8  D5  FE  C8  D3  79  7C  D0  7C  68  DF  C2  70  D5  FD  F8  D3  79  7C  D0  7C  70  DF  C2  F4  D5
FD  F8  D3  7A  40  D0  7C  F8  DF  C2  F4  D5  FD  7C  D3
```

CODING EXAMPLE FOR METEOSAT SATELLITE

As the duration between two time slots on the METEOSAT satellite is one hour, five 12-minute blocks are chained and sent to the DCP for transmission. As a METEOSAT message is 640 bytes long, 10 bytes (hex00) are added to the end of the 630 bytes of the 5 X 12-minute blocks (5 X 126 bytes). Binary from IMFV2.83 format is sent to the DCP without any modification.
Consider the following data set:

Date: March 23 1993 (day 082)
Time of first sample 12:00
Observatory identification: 04342275 (co-latitude 43.4°, longitude 227.5°)
Sensor orientation is XYZF
INTERMAGNET approved filtering
No alert capability
No RMs
Flag #1: 00000000
Flag #2: 00000000

APPENDIX E-2 (Cont'd)

Minute values of C1, C2, C3, C4

Block # 1: minute 0-11

209062	-56	423216	472036
209062	-52	423218	472038
209058	-46	423220	472038
209053	-49	423219	472035
209052	-51	423214	472030
209054	-55	423214	472031
209061	-56	423215	472035
209066	-55	423217	472039
209062	-52	423214	472034
209055	-54	423212	472030
209055	-52	423213	472030
209056	-50	423213	472031

Block # 2: minute 12-23

209059	-45	423215	472034
209057	-45	423214	472032
209059	-40	423216	472035
209057	-42	423214	472032
209054	-40	423213	472030
209053	-42	423214	472030
209048	-45	423214	472028
209046	-47	423217	472030
209045	-45	423217	472030
209044	-46	423217	472029
209043	-44	423214	472026
209045	-43	423215	472028

Block #3 : minute 24-35

209050	-44	423215	472030
209056	-45	423217	472035
209064	-45	423218	472039
209072	-43	423217	472042
209073	-41	423216	472041
209069	-39	423216	472039
209063	-37	423215	472036
209059	-36	423216	472035
209054	-37	423216	472033
209051	-42	423215	472030
209046	-47	423215	472028
209045	-50	423216	472029

Block # 4: minute 36-47

209041	-56	423214	472025
209044	-58	423215	472027
209044	-60	423215	472027
209049	-57	423217	472031
209056	-54	423217	472035
209063	-48	423217	472038
209068	-45	423217	472040
209070	-42	423216	472040
209072	-40	423217	472042
209070	-38	423216	472040
209065	-40	423215	472037
209063	-41	423215	472036

Block # 5: minute 48-59

209067	-39	423217	472039
209064	-41	423216	472037
209059	-42	423215	472034
209058	-41	423215	472034
209061	-40	423214	472034
209063	-37	423215	472036
209060	-37	423215	472034
209060	-38	423213	472033
209063	-39	423213	472034
209063	-40	423212	472033
209068	-37	423215	472038
209071	-33	423217	472041

APPENDIX E-2 (Cont'd)

Hex dump of IMFV2.83 binary of these five 12-minute blocks:
(5 * 126 + 10 trailing zeros = 640 characters)


```
52  00  2D  99  7F  B3  B9  00  00  B2  31  8E  00  00  00  00
00  00  00  00  00  00  00  00  00  00  00  00  00  00  A6  10
C8  1F  30  15  E4  13  A6  10  CC  1F  32  15  E6  13  A2  10
D2  1F  34  15  E6  13  9D  10  CF  1F  33  15  E3  13  9C  10
CD  1F  2E  15  DE  13  9E  10  C9  1F  2E  15  DF  13  A5  10
C8  1F  2F  15  E3  13  AA  10  C9  1F  31  15  E7  13  A6  10
CC  1F  2E  15  E2  13  9F  10  CA  1F  2C  15  DE  13  9F  10
CC  1F  2D  15  DE  13  A0  10  CE  1F  2D  15  DF  13  52  C0
2D  99  7F  B3  B9  00  00  B2  31  8E  00  00  00  00  00  00
00  00  00  00  00  00  00  00  00  00  00  00  A3  10  D3  1F
2F  15  E2  13  A1  10  D3  1F  2E  15  E0  13  A3  10  D8  1F
30  15  E3  13  A1  10  D6  1F  2E  15  E0  13  9E  10  D8  1F
2D  15  DE  13  9D  10  D6  1F  2E  15  DE  13  98  10  D3  1F
2E  15  DC  13  96  10  D1  1F  31  15  DE  13  95  10  D3  1F
31  15  DE  13  94  10  D2  1F  31  15  DD  13  93  10  D4  1F
2E  15  DA  13  95  10  D5  1F  2F  15  DC  13  52  80  2E  99
7F  B3  B9  00  00  B2  31  8E  00  00  00  00  00  00  00  00
00  00  00  00  00  00  00  00  00  00  9A  10  D4  1F  2F  15
DE  13  A0  10  D3  1F  31  15  E3  13  A8  10  D3  1F  32  15
E7  13  B0  10  D5  1F  31  15  EA  13  B1  10  D7  1F  30  15
E9  13  AD  10  D9  1F  30  15  E7  13  A7  10  DB  1F  2F  15
E4  13  A3  10  DC  1F  30  15  E3  13  9E  10  DB  1F  30  15
E1  13  9B  10  D6  1F  2F  15  DE  13  96  10  D1  1F  2F  15
DC  13  95  10  CE  1F  30  15  DD  13  52  40  2F  99  7F  B3
B9  00  00  B2  31  8E  00  00  00  00  00  00  00  00  00  00
00  00  00  00  00  00  00  00  91  10  C8  1F  2E  15  D9  13
94  10  C6  1F  2F  15  DB  13  94  10  C4  1F  2F  15  DB  13
99  10  C7  1F  31  15  DF  13  A0  10  CA  1F  31  15  E3  13
A7  10  D0  1F  31  15  E6  13  AC  10  D3  1F  31  15  E8  13
AE  10  D6  1F  30  15  E8  13  B0  10  D8  1F  31  15  EA  13
AE  10  DA  1F  30  15  E8  13  A9  10  D8  1F  2F  15  E5  13
A7  10  D7  1F  2F  15  E4  13  52  00  30  99  7F  B3  B9  00
00  B2  31  8E  00  00  00  00  00  00  00  00  00  00  00  00
00  00  00  00  00  00  AB  10  D9  1F  31  15  E7  13  A8  10
D7  1F  30  15  E5  13  A3  10  D6  1F  2F  15  E2  13  A2  10
D7  1F  2F  15  E2  13  A5  10  D8  1F  2E  15  E2  13  A7  10
DB  1F  2F  15  E4  13  A4  10  DB  1F  2F  15  E2  13  A4  10
DA  1F  2D  15  E1  13  A7  10  D9  1F  2D  15  E2  13  A7  10
D8  1F  2C  15  E1  13  AC  10  DB  1F  2F  15  E6  13  AF  10
DF  1F  31  15  E9  13  00  00  00  00  00  00  00  00  00  00
```

CODING EXAMPLE FOR GMS SATELLITE

The GMS satellite system requires that DCP data transmission use a long preamble, recommends that the length of time for data block be at least 63 seconds, and that transmitted data conform to a specified character set. A base-44 coding algorithm was developed for converting binary data to the GMS character set. The coded data format follows:

```
                              HEADER 21 BYTES CODED

                             length                 position          frame
Time Day of the year      12 bit    3/4 word       0 word-0.75
     minute of the day    12 bit    3/4 word     0.75word-1.5
offset C1                           1/2 word     1.5 word-2.0
offset C2                           1/2 word     2.0 word-2.5
offset C3                           1/2 word     2.5 word-3.0
offset C4                           1/2 word     3.0 word-3.5
Flag #1 & #2                          1 word     3.5 word-4.5
station ID  colatitude    12 bit    3/4 word     4.5 word-5.25
            longitude     12 bit    3/4 word     5.25word-6.0      -18byte
                                                         (CR-CR-LF)-21byte

__________________________________________________________________________

                         FREE SPACE 27 BYTES CODED
__________________________________________________________________________

D1 Indices and Baseline control     1/2 word     6.0 word-6.5
:
D18   "     "    "        "          1/2 word   15.5 word-15.0     -48byte
                                                        (CR-CR-LF)-51byte
__________________________________________________________________________

                         MINUTE VALUES 157 BYTES CODED
__________________________________________________________________________

C1 for t+0 minute                      1 word   15.0 word-16.0     -54byte
C2 for t+0 minute                      1 word   16.0 word-17.0     -57byte
C3 for t+0 minute                      1 word   17.0 word-18.0     -60byte
C4 for t+0 minute                      1 word   18.0 word-19.0     -63byte
:
C4 for t+4 minute                      1 word    34.0 word-35.0   -111byte
                                                        (CR-CR-LF)-114byte
C1 for t+5 minute                      1 word    35.0 word-36.0   -117byte
:
C4 for t+9 minute                      1 word    54.0 word-55.0   -174byte
                                                        (CR-CR-LF)-177byte
C1 for t+10 minute                     1 word    55.0 word-56.0   -180byte
:
C1 for t+11 minute                     1 word    59.0 word-60.0   -192byte
C2 for t+11 minute                     1 word    60.0 word-61.0   -195byte
C3 for t+11 minute                     1 word    61.0 word-62.0   -198byte
C4 for t+11 minute                     1 word    62.0 word-63.0   -201byte

CRC                                    1 word    63.0 word-64.0   -204byte
                                                    ('='-CR-CR-LF)-208byte
```

Time framing for GMS

A multiple data transmission (12-minute data block repeated 3 times) may be used to satisfy the GMS minimum block transmission time of approximately 63 seconds. The time framing for GMS would be:

```
no-signal carrier         5.0 second  : 5.0 sec
bit synchronization       2.5         : 7.5
word synchronization      0.15        : 7.65
address                   0.31        : 7.96
first  (64*3+16-1)*8/100 16.56        :24.52  (177 bytes)
second (64*3+16-1)*8/100 16.56        :41.08  (177 bytes)
last   (64*3+16)*8/100   16.64        :57.72  (178 bytes)
EOT-EOT-EOT               0.24        :57.96
```

The following table shows time slots assigned to DCPs. Each table line represents 60 seconds, the station ID is placed at the beginning of a data transmission block, '....' is for the no-signal (carrier only) period, '--' is for synchronization sequence, and '==' is for the data block.

Assigned time slots for the GMS coding would allow 58 seconds per transmission and 7 seconds guard time. This would allow 11 observatories to transmit every 12 minutes.

```
min sec0....*....1....*....2....*....3....*....4....*....5....*....
12*(n) .....--M01================================================__
  +01  _____.....--M02=============================================
  +02  ===_______.....--M03========================================
  +03  ========_______.....--M04===================================
  +04  =============_______.....--M05==============================
  +05  ==================_______.....--M06=========================
  +06  =======================_______.....--M07====================
  +07  ============================_______.....--M08===============
  +08  =================================_______.....--M09==========
  +09  ======================================_______.....--M10=====
  +10  ===========================================_______.....--M11
  +11  ================================================____________
12(n+1).....--M01================================================__
  :
```

Base-44 Coding for GMS

The characters used on the GMS system are: LF CR SP ' ( ) + , - . / 0 1 2 3 4 5 6 7 8 9 : = ? A B C D E F G H I J K L M N O P Q R S T U V W X Y Z (TOTAL 50). The base-44 character set is shown in Table 1.

Each IMFV2.83 data block is encoded by dividing the data block into 16-bit integers. Signed integers are represented by 2's complement. Each integer value is converted to 3 base-44 numbers, <n1,-n2,n3>, the most significant being n1 and the least significant n3. Each base-44 number may be represented by a base-44 character from Table 1. Example conversions are shown below:

```
decimal   base-44     base-44
number    number      char
     0    < 0, 0, 0>  000
     1    < 0, 0, 1>  001
    43    < 0, 0,43>  00?
    44    < 0, 1, 0>  010
 32767    <16,40,31>  G-V
    -1    <43,43,43>  ???
   -44    <43,43, 0>  ??0
 -1935    <43, 0, 1>  ?01
-32768    <27, 3,12>  R3C
```

Table 1

DIGIT	BASE-44	DIGIT	BASE-44
< 0>	0	<22>	M
< 1>	1	<23>	N
< 2>	2	<24>	O
< 3>	3	<25>	P
< 4>	4	<26>	Q
< 5>	5	<27>	R
< 6>	6	<28>	S
< 7>	7	<29>	T
< 8>	8	<30>	U
< 9>	9	<31>	V
<10>	A	<32>	W
<11>	B	<33>	X
<12>	C	<34>	Y
<13>	D	<35>	Z
<14>	E	<36>	(
<15>	F	<37>	)
<16>	G	<38>	+
<17>	H	<39>	,(comma)
<18>	I	<40>	-(hyphen)

APPENDIX E-3

IMFV1.23 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

Magnetic data, with tenth-nanotesla resolution, are organized on a day file basis. One file contains 24 one-hour blocks, each containing 60 minutes worth of values. Blocks of 60 minutes of data are transmitted. Blocks are padded with 9's if incomplete. Information is coded in ASCII.

File name: To remain compatible with all operating systems, the file name is limited to 8 characters and will contain the date and the three-letter code as an extension. eg: MAR1591.BOU for Boulder, March 15, 1991; and JUN2391.OTT for June 23, 1991 at Ottawa.

Description of the header block (64 characters including CrLf)

IDC_DDDDDDD_DOY_HH_COMP_T_GIN_COLALONG_DECBAS_RRRRRRRRRRRRRRRRCrLf

IDC	:	Indicates the IAGA three letter observatory identification (ID) code eg: BOU for Boulder, OTT for Ottawa, LER for Lerwick, etc.
DDDDDDD	:	Indicates the date, eg: FEB1591 for February 15, 1991.
DOY	:	Indicates day of the year (1-366)
HH	:	Indicates the Hour (0-23). The first line following the header will contain the values corresponding to minute 0 and 1 of this hour. The first value of the day file is hour 0 minute 0.
COMP	:	Order in which the components are listed, can be HDZF, HDZG, XYZF, XYZG. G represents the difference between a measured 'Scalar' F and a computed 'vector' F: G = F(vector) - F(scalar). All components excluding D must be in tenths of nT. D must be in hundredths of minutes, east. The F or G component should be included only if it is measured from a scalar instrument independent of the other 3 components otherwise it must be filled with 999999.
T	:	One-letter code for data type. R=Reported, A=Adjusted, Q=Quasi-definitive, D=Definitive data. **Reported data** are defined as: the raw data obtained from the IMO, either by satellite, computer link, or other means. It will be formatted in either version IMFV2.8N (binary) or IMFV1.2N (ASCII,) without any RM (Reference Measurements), or other modifications applied to it. **Adjusted data** are defined as: the Reported data with RM, spike removal, timeshifts, and/or other modifications applied to it. It is emphasized that only one (1) adjusted version of the data would be allowed, to be completed within 7 days of receipt of the Reported data to prevent the proliferation of multiple versions of the Adjusted data. **Quasi-definitive data** are defined as data that have been corrected using provisional baselines. Produced soon after their acquisition, their accuracy is intended to be very close to that of an observatory's definitive data product. 98% of the differences between quasi-definitive and definitive data (X, Y, Z) monthly mean values should be less than 5nT. **Definitive data** are defined as the final adopted data values. Definitive data will only be distributed by the institution responsible for the observatory.
GIN	:	Three-letter code for GIN responsible for processing the station (IMO) data eg: EDI(Edinburgh), GOL(Golden), OTT(Ottawa), PAR(Paris).
COLALONG	:	Colatitude and east longitude of the observatory in tenths of degrees.
DECBAS	:	Baseline declination value in tenths of minutes East (0-216,000). Declination baseline values to be provided annually. If components are X,Y,Z then DECBAS=000000. The DECBAS value is used to allow declination data to exceed 166.66 degrees (which is the limit of the declination elements in each data record without any offset). If the declination is > 166 degrees at an observatory then a DECBAS value should be selected such that the minute samples lie between 0 and 166 degrees. The declination baseline DECBAS should be subtracted from the minute data samples before coding them.
RRR..RRR	:	Reserved 16 bytes of R-characters for future use.
_	:	Indicates a space character.
CrLf	:	Indicates a Carriage return, Line feed.

Missing values for a vector component must be coded as a space (for the sign bit) followed by six 9 digits: _999999
Missing values for the scalar component must be coded as six 9 digits: 999999

IMFV1.23 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

Description of data space (64 characters per line including CrLf)

Component values are coded as signed integers, right-justified with a field width of 7. Total field (F) values are coded as unsigned integers, right-justified with a field width of 6. The field widths must be maintained, either through zero-filling or space-filling. The '+' sign for positive values is optional.

Two (2) minutes of data are concatenated on the same line

```
AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF__AAAAAAA_BBBBBBB_CCCCCCC_FFFFFFCrLf
(values for minute 0)            (values for minute 1)
.                                .
.                                .
.                                .
AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF__AAAAAAA_BBBBBBB_CCCCCCC_FFFFFFCrLf
(values for minute 58)           (values for minute 59)
```

AAAAAAA	: Indicates Component 1 data field (H,X, etc.).
BBBBBBB	: Indicates Component 2 data field (D,Y, etc.).
CCCCCCC	: Indicates Component 3 data field (Z,I, etc.).
FFFFFFF	: Indicates Total Field data field.
_	: Indicates space character.
CrLf	: Indicates Carriage Return and Line Feed.

Sample of missing values

_999999__999999__999999_999999___999999__999999__999999_999999CrLf

This example represents all components as missing for the first two minutes of the hour .
'_' indicates a space character.

IMFV1.22 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

Magnetic data, with tenth-nanotesla resolution, are organized on a day file basis. One file contains 24 one-hour blocks, each containing 60 minutes worth of values. Blocks of 60 minutes of data are transmitted. Blocks are padded with 9's if incomplete. Information is coded in ASCII.

File name: To remain compatible with all operating systems, the file name is limited to 8 characters and will contain the date and the three-letter code as an extension. eg: MAR1591.BOU for Boulder, March 15, 1991; and JUN2391.OTT for June 23, 1991 at Ottawa.

Description of the header block (64 characters including CrLf)

IDC_DDDDDDD_DOY_HH_COMP_T_GIN_COLALONG_DECBAS_RRRRRRRRRRRRRRRRCrLf

IDC	:	Indicates the IAGA three letter observatory identification (ID) code eg: BOU for Boulder, OTT for Ottawa, LER for Lerwick, etc.
DDDDDDD	:	Indicates the date, eg: FEB1591 for February 15, 1991.
DOY	:	Indicates day of the year (1-366)
HH	:	Indicates the Hour (0-23). The first line following the header will contain the values corresponding to minute 0 and 1 of this hour. The first value of the day file is hour 0 minute 0.
COMP	:	Order in which the components are listed, can be HDZF, XYZF. All components excluding D must be in tenths of nT. D must be in hundredths of minutes, east. The F component should be included only if it is measured from a scalar instrument independent of the other 3 components otherwise it must be filled with 999999.
T	:	One-letter code for data type. R=Reported, A=Adjusted, D=Definitive data. **Reported data** are defined as: the raw data obtained from the IMO, either by satellite, computer link, or other means. It will be formatted in either version IMFV2.8N (binary) or IMFV1.2N (ASCII,) without any RM (Reference Measurements), or other modifications applied to it. **Adjusted data** are defined as: the Reported data with RM, spike removal, timeshifts, and/or other modifications applied to it. It is emphasized that only one (1) adjusted version of the data would be allowed, to be completed within 7 days of receipt of the Reported data to prevent the proliferation of multiple versions of the Adjusted data. **Definitive data** are defined as the final adopted data values. Definitive data will only be distributed by the institution responsible for the observatory.
GIN	:	Three-letter code for GIN responsible for processing the station (IMO) data eg: EDI(Edinburgh), GOL(Golden), OTT(Ottawa), PAR(Paris).
COLALONG	:	Colatitude and east longitude of the observatory in tenths of degrees.
DECBAS	:	Baseline declination value in tenths of minutes East (0-216,000). Declination baseline values to be provided annually. If components are X,Y,Z then DECBAS=000000.
RRR..RRR	:	Reserved 16 bytes of R-characters for future use.
_	:	Indicates a space character.
CrLf	:	Indicates a Carriage return, Line feed.

Missing values for a vector component must be coded as a space (for the sign bit) followed by six 9 digits: _999999
Missing values for the scalar component must be coded as six 9 digits: 999999

IMFV1.22 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

Description of data space (64 characters per line including CrLf)

Component values are coded as signed integers, right-justified with a field width of 7. Total field (F) values are coded as unsigned integers, right-justified with a field width of 6. The field widths must be maintained, either through zero-filling or space-filling. The '+' sign for positive values is optional.

Two (2) minutes of data are concatenated on the same line

```
AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF__AAAAAAA_BBBBBBB_CCCCCCC_FFFFFFCrLf
(values for minute 0)               (values for minute 1)
.                                   .
.                                   .
.                                   .
AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF__AAAAAAA_BBBBBBB_CCCCCCC_FFFFFFCrLf
(values for minute 58)              (values for minute 59)
```

AAAAAAA	: Indicates Component 1 data field (H,X, etc.).
BBBBBBB	: Indicates Component 2 data field (D,Y, etc.).
CCCCCCC	: Indicates Component 3 data field (Z,I, etc.).
FFFFFFF	: Indicates Total Field data field.
_	: Indicates space character.
CrLf	: Indicates Carriage Return and Line Feed.

Sample of missing values

_999999__999999__999999_999999___999999__999999__999999_999999CrLf

This example represents all components as missing for the first two minutes of the hour .
'_' indicates a space character.

APPENDIX E-4

IBFV2.00 INTERMAGNET BASELINE FORMAT (2009 and AFTER)

This file format is to be used to provide baselines for use in examining equipment and environmental quality (mainly thermal stability of the variometers) and for inclusion on the INTERMAGNET yearly DVD. This format makes room for all published components, including a baseline to scalar data. After a one-line header, the first section contains the observed baseline values on the days when they are measured. Consequently the number of entries will depend upon the schedule for absolute measurements at the observatory. The second section contains adopted baseline values, representing each day of the year. The third section for comments is mandatory. This comment section must include a brief description of the baseline adoption method.

```
COMP_HHHHH_FFFFF_IDC_YEARCrLf
DDD_aaaaaa.aa_bbbbbb.bb_zzzzzz.zz_ssssss.ssCrLf
. . .
. . .
. . .
DDD_aaaaaa.aa_bbbbbb.bb_zzzzzz.zz_ssssss.ssCrLf
*CrLf
001_AAAAAA.AA_BBBBBB.BB_ZZZZZZ.ZZ_SSSSSS.SS_DDDD.DD_mCrLf
002_AAAAAA.AA_BBBBBB.BB_ZZZZZZ.ZZ_SSSSSS.SS_DDDD.DD_mCrLf
003_AAAAAA.AA_BBBBBB.BB_ZZZZZZ.ZZ_SSSSSS.SS_DDDD.DD_mCrLf
. . .
. . .
. . .
366_AAAAAA.AA_BBBBBB.BB_ZZZZZZ.ZZ_SSSSSS.SS_DDDD.DD_mCrLf
*CrLf
Comments:CrLf
.....................................................CrLf
.....................................................CrLf
```

Component values are coded as signed float numbers, right justified with format (1X,F9.2). DeltaF values (denoted as DDDD.DD) are coded as signed float numbers, right justified with format (1X,F7.2). The field widths must be maintained, either through zero-filling or space-filling in order to have records of fixed length: every line is 43 characters long in section one, and 53 characters long in section two excluding terminator CrLf or Lf. Comment lines should not exceed 53 characters long.

COMP	: Order of components XYZF, DIF_, HDZF, UVZF (see Note 1).
HHHHH	: Annual mean value of H component in nT.
FFFFF	: Annual mean value of F component in nT.
IDC	: Official IAGA three-letter station code in capital letters.
YEAR	: 4-digit Year: eg, 2009.
DDD	: Day of the year.
aaaaaa.aa	: Observed baseline of X, D, H or U in nT or minutes (absolute - variometer)
bbbbbb.bb	: Observed baseline of Y, I, D or V in nT or minutes (absolute - variometer)
zzzzzz.zz	: Observed baseline of Z or F in nT (absolute - variometer)
ssssss.ss	: Observed baseline of Scalar F in nT (absolute - scalar, See Note 5)
AAAAAA.AA	: Adopted baseline value of X, D, H or U in nT or minutes.
BBBBBB.BB	: Adopted baseline value of Y, I, D or V in nT or minutes.
ZZZZZZ.ZZ	: Adopted baseline value of Z, or F in nT.
SSSSSS.SS	: Adopted baseline value of Scalar F in nT. (absolute - scalar, See Note 5)
DDDD.DD	: Representative value of Delta F for this day (see Note 2).
m	: Discontinuity marker (valid values c or d - see Note 3).
*	: Section separator.
_	: Space character.
CrLf	: Carriage return, Line feed.

APPENDIX E-4 (Cont'd)

IBFV2.00 INTERMAGNET BASELINE FORMAT (2009 and AFTER)

File name convention is IAGYEAR.BLV e.g. BFE2008.BLV

where IAG = 3-letter observatory IAGA code
YEAR = 4-digit year.

Notes :
1. The codes XYZF, DIF_, HDZF, UVZF are the only supported codes of the components which must be listed in specified order within sections one and two.

2. Delta F is defined as:
   Delta F = F(v) - F(s).
   Where F(v) represents the total field value calculated from the main observatory instrument ('vector F') and F(s) represents the total field from an independent instrument ('scalar F'). Both F(v) and F(s) must be corrected to the location in the observatory where geomagnetic absolute observations are made.

3. Discontinuity marker: c indicates that the baselines for all components form a continuous series with the previous day, d indicates a discontinuity in the baseline of one or more components (i.e. step) between the current day and the preceding one. This is to allow the baselines to be plotted at an appropriate scale. A discontinuity is defined as a known operational change such as an instrument re-alignment.

4. Missing values must be replaced by 99999.00 for D, H, X, Y, Z, F and by 999.00 for Delta F. Components that are not observed, which may include Scalar F (SSSSSS.SS) and Delta F (DDDD.DD), must be coded 88888.00 and 888.00 respectively.

5. The observed and adopted F baselines represent the DIFFERENCE in the F component between the absolute position and the continuously recording scalar instrument. Pier corrections are not applied to the data before computing the baselines.

APPENDIX E-4 (Cont'd)

IBFV1.20 INTERMAGNET BASELINE FORMAT (2008 and BEFORE)

This format is to be used to provide baselines for use in examining equipment performance and for inclusion on the INTERMAGNET DVD. The first section contains the observed baseline values on those days on which they were measured. Consequently the number of entries will depend upon the schedule for absolute measurements at that observatory. The second section contains adopted baseline values representing each day of the year. A comment section is also provided.

```
COMP_HHHHH_IDC_YEARCrLf
DDD_AAAAAAA_BBBBBBB_ZZZZZZZ CrLf.
   .        .            .             .       .
   .        .            .             .       .
   .        .            .             .       .
DDD_AAAAAAA_BBBBBBB_ZZZZZZZ CrLf.
*
001_AAAAAAA_BBBBBBB_ZZZZZZZ_FFFFF CrLf.
002_AAAAAAA_BBBBBBB_ZZZZZZZ_FFFFF CrLf.
003_AAAAAAA_BBBBBBB_ZZZZZZZ_FFFFF CrLf.
 .
 .
 .
366_AAAAAAA_BBBBBBB_ZZZZZZZ_FFFFF CrLf.
*
Comments:
```

Component values are coded as signed integers, right-justified with a field width of 7. Total field (Delta F) values are coded as signed integers, right-justified with a field width of 5. The field widths must be maintained, either through zero-filling or space-filling. The '+' sign for positive values is optional.

COMP	:	Order of components HDZF, XYZF, DIF, UVZF
HHHHHH	:	Annual mean value of H component in nT.
IDC	:	IAGA three-letter observatory ID code eg: BOU for Boulder, OTT for Ottawa, LER for Lerwick, etc.
YEAR	:	4-digit Year: for example, 1991.
DDD	:	Day of the year
AAAAAAA	:	Signed value of H, D, U or X in 0.1 nT
BBBBBBB	:	Signed value of D, I, V or Y in 0.1 nT or 0.1 min of arc for D
ZZZZZZZ	:	Signed value of Z or F in 0.1 nT
FFFFF	:	Signed value of Delta F, the difference between calculated and observed value of F (by a proton magnetometer) in 0.1 nT
*	:	Section separator.
_	:	Space character
CrLf	:	Carriage return, Line feed

Missing values must be replaced by 999999 for D, H, X, Y, Z and by 9999 for F.

File name convention is IAGYR.BLV

where IAG = 3-letter observatory IAGA code
YR = 2-digit year.

APPENDIX E-5

IAGA2002 INTERMAGNET EXCHANGE FORMAT (Spreadsheet compatible)

This ASCII Exchange Format, adopted in August 2001 and revised in December 2001 and in July 2003, is intended as a data exchange format for geomagnetic data (samples and means) from observatories and variometer stations at time intervals from millisecond up to and including monthly means. The format comprises:

- Twelve (12) mandatory file header records.
- Unlimited optional comment records.
- One (1) mandatory data header record.
- A series of data records.
- **Every record is 70 characters long** plus the machine-dependent carriage return / line feed.

Pad records with spaces if needed. Data records report exactly 4 magnetic field elements (DHIF, DHZF, or XYZF). Use missing data values (8's or 9's) if fewer than 4 elements are available.

THE 12 MANDATORY FILE HEADER RECORDS

Mandatory header and optional comment records begin with a space character in column 1 and end with the vertical bar | (ASCII 124) in column 70. Content labels begin in column 2 and descriptions begin in column 25.

- This ***Format*** is designated IAGA-2002.
- ***Source of Data*** is the name of the institute responsible for collecting the data.
- Please spell the entire ***Station Name***; do not use abbreviations. Capitalize the first letter.
- The ***IAGA Code*** is the official IAGA 3-letter station code. It should be in capital letters and correspond to the IAGA list of magnetic observatories. Variation stations must check observer suggested 3-letter codes against the IAGA list (WDC SEG, Boulder) and confirm through the IAGA Division V WG1 or leave the code blank.
- Location of the station is reported to the one thousandth degree in ***Geodetic Latitude*** (positive north) from -90 to 90 degrees and in
- ***Geodetic Longitude*** (positive east) from -180 to 180 or 0 to 360 degrees.
- Report ***Elevation*** in meters above mean sea level.
- ***Reported*** refers to the magnetic field elements contained in the data record, **in the order recorded in data record**. Valid values are HDIF, DHIF, HDZF, DHZF, and XYZF. Use E/V instead of D/I for declination/inclination given in intensity units (ONLY if data type is variation).
- ***Sensor Orientation*** is the physical orientation of the observing instruments, i.e. XYZ, HDZ.
- ***Digital Sampling*** is the rate (in seconds) of the data sampling of the magnetic field sensor (instrument) or the digitizing interval for analogue data.
- ***Data Interval Type*** is the mean or instantaneous time interval of the data. Common values include 1-minute (00:30-01:29), 1-minute (00:00-00:59), 1-hour (00-59), 1-day (00-23) and 1-month (01-31); the last day could also be 30, 29, or 28. There are many possible intervals, including a fraction of a second (instant value), averages by 1-second (501-1500), 1- second (0-1000), 10 second, or 2.5 minute. **Define the type of mean and how values are centered in the comment section**.
- ***Data Type*** is provisional, definitive, or variation

THE OPTIONAL COMMENT HEADER RECORDS

Use these records to record important information concerning the data that is not contained in the defined fields. Types of information may include the type of means and how the mean values are centered, important gaps in the data record, or explanations of missing values (9 filled element field).

- Every record begins with a space character in column 1 and # (hash or number sign) in column 2.
- The end of each record is indicated with a vertical bar | (ASCII 124) in column 70.

- For transmission of incomplete day files include two additional optional comment headers stating the start time and duration in seconds. These records must have the form:
  #Start Time hh:mm:ss
  #Duration-in-seconds sssss
- If the data file contains absolute values (Data Type provisional or definitive), include the formula for computing the missing (non-reported) magnetic elements. For example, if an observatory reports XYZF, the comments should contain the formula for computing HDI (see sample data header and data record for 1-minute values).
- If the data file contains variometer values without considering base line values (Data Type variation), formula and constants are to be given to convert the recorded magnetic elements into others or to convert angular units into nT or vice versa. The possible conversions are:
  - E = D * Ha * arc(1')
  - V = I * Fa * arc(1')
  - X = H * cos(Da) – E* sin(Da)
  - Y = H * sin(Da) + E* cos(Da)
  - Z = F * sin(Ia) + V * cos(Ia)
  - F = Z * sin(Ia) + H * cos(Ia)
  - H = X * cos(Da) + Y * sin(Da) = F * cos(Ia) – V * sin(Ia)
  - E = Y * cos(Da) – X * sin(Da)
  - V = Z * cos(Ia) – H * sin(Ia)

  X, Y, Z, H, F, E, V in nT; D, I in minutes of arc
  arc(1') = 2.9089E-04 = 0.00029089
  Ha, Fa, Da, Ia : approximate values of H, F, D, I (eg the most recent annual mean value or a value from the IGRF)
  The formula and constants are to be given in additional optional comment header lines (see sample data header and data record for 1-second values).

THE MANDATORY DATA HEADER RECORD

The mandatory data-header record contains column headers useful for multi- station analysis. Elements, both type and order, are indicated in the file-header field ***Reported***.

- The date and time headers are DATE, TIME, and DOY (day of year).
- The magnetic element headers comprise 4 letters: 3 letters for the observatory IAGA code and 1 letter for the magnetic element reported. Valid values are H, D (or E), I (or V), X, Y, Z, F. The column headers are space delimited.
- The end of each record is indicated with a vertical bar | (ASCII 124) in column 70.

THE DATA RECORDS

The data records contain the date, time, and magnetic field elements reported. Report data to the least significant digit. Indicate missing data with 99999 (e.g., 99999.00). If an element is not observed, please record 88888 in that field. The format for field elements is 4(1X, F9.2). Each record is exactly 70 characters long plus the machine dependent carriage return / line feed.

- DATE is the calendar date in ISO YYYY-MM-DD format (4-digit year, month as 01-12, day as 01-31).
- TIME is in ISO hh:mm:ss.sss format (hour as 0-24, minute as 0-59, second as 0-59 Note: if the hour is 24, the minute and second must be 0). Values beyond the time interval of the means being reported must be zero-filled i.e. 14:01:00.000 for 1 minute data for the 14th hour, first minute. Describe the method of average, i.e., centered to the hour for hourly means, in the comments area.
- DOY is the day of the year, from 1 - 365 (or 366 for leap years).
- D and I are reported in angular units of minutes of arc to the precision of the instruments. F, H, X, Y, Z, E, and V are reported in nanotesla and a fraction of nT.

RECOMMENDED FILE NAME PROCEDURE

To improve the ease with which data are exchanged and recognized, IAGA recommends the following guidelines and style for naming files containing magnetic observatory data. The recommendations closely follow the current International Standards Organization (ISO) Level II recommendations, and are fully compliant with both the Joliette extension to Level II and to the proposed modifications for the ISO standard. These recommendations are for data exchange and do not necessarily apply to data archive. Some changes have been made in this section in July 2003 to allow for existence of multiple fragments of data starting at different times (which is a possibility for some data transmission systems) and to ease usage with compression programs.

- File names are composed of two parts, the base name and a three-character extension. A full stop (period) separates the base from the extension. The base name may be up to 27 characters long. The extension is exactly three characters (total file name length not to exceed 31 characters). This format is sometimes referred to as the "27.3" format. BASENAME (1 to 27 characters) "." EXTENSION (3 characters).
  Ex. my_file_name.dat
- File names are composed of lower case a-z, 0-9, underscore "_", and dash "-" characters. No spaces, unusual characters (i.e. *, /, \, :, ;, ?) or upper case characters allowed.
- File names must begin with the IAGA 3-Letter Code, Date, and Type of data. The Extension defines the Data Interval (monthly, daily, hourly, minute, or second data). The Extension is duplicated in the last three characters of the base name, so that if the Extension is stripped on compression the Data Interval is not lost. The file name only indicates the general data interval, specific information is contained in the file header Data Interval field (i.e. 2.5 and 1-minute averages are both "minute" data, 10 second averages and 1 second instantaneous are both "second" data).
- The first several characters in the base name are strictly defined. Files may be further defined with the remaining characters by using an underscore "_" to separate the standard name. For example, naq20020101d.min and naq20020101d_2-5.min are both acceptable names for 2.5 minute definitive data from Narsarsuaq.

General format: iagyyyymmddtint.int

Where:

iag = IAGA 3-letter observatory code
yyyy = four digit year (i.e. 2002)
mm = two digit month (i.e. 01 for January, 12 for December)
dd = two digit day of month (01-31)
t = type of data (p - provisional, d - definitive, v - variation)
int = data interval (mon - monthly, day - daily, hor - hourly, min - minute, sec - second).

Comment	Data Interval	Files	File Name Pattern	Example Name
1	Monthly	Year	iagyyyytint.int	naq2002dmon.mon
2	Daily	Year	iagyyyytint.int	naq2002dday.day
3	Hourly	Month	iagyyyymmtint.int	naq200201phor.hor
4	Minute	Day	iagyyyymmddtint.int	naq20020101pmin.min
5	Second	Day	iagyyyymmddtint.int	naq20020211vsec.sec

1.File contains 1 year of definitive monthly data for 2002 from Narsarsuaq.
2.File contains 1 year of definitive daily data for 2002 from Narsarsuaq.
3.File contains 1 month of provisional hourly data for January 2002 from Narsarsuaq.
4.File contains 1 day of provisional minute data for 1 January 2002 from Narsarsuaq.
5.File contains 1 day of variation second data for 11 February 2002 from Narsarsuaq.

Additional format to handle multiple fragments of data starting at different times: iagyyyymmddhhMMsstint.int

Where:

iag = IAGA 3-letter observatory code
yyyy = four digit year (i.e. 2002)
mm = two digit month (i.e. 01 for January, 12 for December)
dd = two digit day of month (01-31)
hh = hour at which data starts (00-23)
MM = minute at which data starts (00-59)
ss = second at which data starts (00-59)
t = type of data (p - provisional, d - definitive, v - variation)
int = data interval (mon - monthly, day - daily, hor - hourly, min - minute, sec - second)

Comment	Data Interval	Files	File Name Pattern	Example Name
1	Minute	Part-day	iagyyyymmddhhMMtint.int	clf200306121320vmin.min
2	Second	Part-day	iagyyyymmddhhMMsstint.int	clf20030612132000vsec.sec

1.File contains part-day of 1-minute variation data from CLF for 12 June 2003, starting at 13:20
2.File contains part-day of 1-second variation data from CLF for 12 June 2003, starting at 13:20:00

<u>SAMPLE OF IAGA-2002 FORMAT JULY 2003 REVISION</u>

<u>SAMPLE DATA HEADER AND DATA RECORD FOR 1-MINUTE VALUES</u>

```
 Format                 IAGA-2002                                     |
 Source of Data         Danish Meteorological Institute               |
 Station Name           Narsarsuaq                                    |
 IAGA Code              NAQ                                           |
 Geodetic Latitude      61.160                                        |
 Geodetic Longitude     314.560                                       |
 Elevation              4                                             |
 Reported               XYZF                                          |
 Sensor Orientation     DIF                                           |
 Digital Sampling       0.01 seconds                                  |
 Data Interval Type     Filtered 1-minute (00:30 - 01:29)             |
 Data Type              Definitive                                    |
 # This area is where the data source or distributor can include      |
 # any additional information needed for proper use of data.  For     |
 # example, the observers name and contact, notes on a change of      |
 # instrumentation, reasons for missing data values, definition of    |
 # observed values, geomagnetic location of the observatory, etc.     |
 # This area should also contain the formula for computing the non-   |
 # reported elements and components of the INTERMAGNET binary         |
 # format which do not fit elsewhere.  These include:                 |
 # D-conversion:                                                      |
 # = H/3438*10000.                                                    |
 # which is word 8 in the INTERMAGNET binary format and is used       |
 # to convert variations of D in minutes of arc <-> nT.  Please       |
 # note that all of the header records and comment records begin      |
 # with a space in column 1, end with a | (ASCII 124), and are        |
 # padded with spaces - never with tabs.                              |
 # H = squareroot(X*X + Y*Y), cos D = X/H, sin I = Z/F                |
DATE       TIME         DOY     NAQX      NAQY      NAQZ      NAQF    |
2001-03-13 00:00:00.000 072     10800.11  -6100.23  53381.51  54801.12
2001-03-13 00:01:00.000 072     10800.31  -6100.20  53381.51  54801.12
2001-03-13 00:02:00.000 072     10801.11  -6101.23  99999.00  54801.12
2001-03-13 00:03:00.000 072     10803.12  -6100.23  99999.00  54801.12
```

SAMPLE DATA HEADER AND DATA RECORD FOR HOURLY VALUES

The header record for Data Interval Type might read:
Data Interval Type   1-hour (00 - 59). Note filler for non-reported element.

```
DATE       TIME         DOY     NAQX      NAQY      NAQZ      NAQF    |
2001-03-13 00:00:00.000 072     10800.11  -6100.23  53381.51  88888.00
2001-03-13 01:00:00.000 072     10800.31  -6100.20  53381.51  88888.00
2001-03-13 02:00:00.000 072     10801.11  -6101.23  53381.50  88888.00
2001-03-13 03:00:00.000 072     10803.12  -6100.23  99999.00  88888.00
```

SAMPLE DATA HEADER AND DATA RECORD FOR MONTHLY VALUES

The header record for Data Interval Type might read:
Data Interval Type   1-month (01 - 31). Note filler for non-reported element.

```
DATE       TIME         DOY      NAQX     NAQY      NAQZ      NAQF    |
2001-01-15 00:00:00.000 015     10800.11  -6100.23  53381.51  88888.00
2001-02-14 00:00:00.000 045     10800.31  -6100.20  53381.51  88888.00
2001-03-15 00:00:00.000 074     10801.11  -6101.23  53381.50  88888.00
2001-04-15 00:00:00.000 105     10803.12  -6100.23  99999.00  88888.00
```

SAMPLE DATA HEADER AND DATA RECORD FOR 1-SECOND VALUES

```
 Format                 IAGA-2002                                    |
 Source of Data         Danish Meteorological Institute              |
 Station Name           Narsarsuaq                                   |
 IAGA CODE              NAQ                                          |
 Geodetic Latitude      61.160                                       |
 Geodetic Longitude     314.560                                      |
 Elevation              4                                            |
 Reported               HEZF                                         |
 Sensor Orientation     HEZF                                         |
 Digital Sampling       1 seconds                                    |
 Data Interval Type     1-second instantaneous                       |
 Data Type              Variation                                    |
 # This area should contain additional information needed            |
 # in order to transform the reported elements. For the data in this |
 # sample information about the declination at the observatory is   |
 # needed in order to tranform the variation data from HEZ to the    |
 # widely used XYZ orientation. Also information about the value of  |
 # horizontal field H can be useful to convert E-variations in nT to |
 # variations in minutes of arcs.                                    |
 # E = D * Ha * 0.00029089                                           |
 # Ha = 17123.45                                                     |
 # X = H * cos(Da) - E* sin(Da)                                      |
 # Y = H * sin(Da) + E* cos(Da)                                      |
 # Da = 312.89 minutes of arc                                        |
DATE       TIME         DOY     NAQH      NAQE      NAQZ      NAQF    |
2001-03-13 00:00:00.000 072       800.11   -100.23    381.51  54801.12
2001-03-13 00:00:01.000 072       800.31   -100.20    381.51  54802.32
2001-03-13 00:00:02.000 072       801.11   -101.23  99999.00  54803.22
2001-03-13 00:00:03.000 072       803.12   -100.23  99999.00  54803.43
```

SAMPLE DATA HEADER AND DATA RECORD FOR 5-MILLISECOND VALUES

The header record for Data Interval Type might read:
Data Interval Type 5-millisecond (instantaneous values). Note filler for missing element.

```
DATE       TIME         DOY     NAQX      NAQY      NAQZ      NAQF     |
2001-03-13 00:00:00.000 072     10800.11  -6100.23  53381.51  99999.00
2001-03-13 00:00:00.005 072     10800.31  -6100.20  53381.51  99999.00
2001-03-13 00:00:00.010 072     10801.11  -6101.23  53381.50  54801.10
2001-03-13 00:00:00.015 072     10803.12  -6100.23  99999.00  54801.24
```

APPENDIX F-1

FILTER COEFFICIENTS TO PRODUCE ONE MINUTE VALUES

Time in Seconds	Coef. for One Second Data	Coef. for Five Second Data	Coef. For Ten Second Data	Time in Seconds	Coef. for One Second Data	Coef. for Five Second Data	Coef. for Ten Second Data
t_{0}	0.02519580	0.12578865	0.25100743	t_{26}	0.00661811		
t_{1}	0.02514602			t_{27}	0.00595955		
t_{2}	0.02499727			t_{28}	0.00534535		
t_{3}	0.02475132			t_{28}	0.00477552		
t_{4}	0.02441104			t_{30}	0.00424959	0.02121585	0.04233562
t_{5}	0.02398040	0.11972085		t_{31}	0.00376666		
t_{6}	0.02346437			t_{32}	0.00332543		
t_{7}	0.02286881			t_{33}	0.00292430		
t_{8}	0.02220039			t_{34}	0.00256140		
t_{9}	0.02146643			t_{35}	0.00223468	0.01115655	
t_{10}	0.02067480	0.10321785	0.20596804	t_{36}	0.00194194		
t_{11}	0.01983377			t_{37}	0.00168089		
t_{12}	0.01895183			t_{38}	0.00144918		
t_{13}	0.01803763			t_{39}	0.00124449		
t_{14}	0.01709976			t_{40}	0.00106449	0.00531440	0.01060471
t_{15}	0.01614667	0.08061140		t_{41}	0.00090693		
t_{16}	0.01518651			t_{42}	0.00076964		
t_{17}	0.01422707			t_{43}	0.00065055		
t_{18}	0.01327563			t_{44}	0.00054772		
t_{19}	0.01233892			t_{45}	0.00045933	0.00229315	
t_{20}	0.01142303	0.05702885	0.11379931	t_{46}			
t_{21}	0.01053338			t_{47}			
t_{22}	0.00967467			t_{48}			
t_{23}	0.00885090			t_{49}			
t_{24}	0.00806530			t_{50}			0.00178860
t_{25}	0.00732042	0.03654680					

APPENDIX G-1

INTERMAGNET MEMBERSHIP APPLICATION (V-2.6 September 2012)

An Institution must apply for membership in INTERMAGNET by mailing this completed application form to:

Christopher W. Turbitt,
INTERMAGNET
c/o British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
UK

This application form is also available in PDF, Word and WordPerfect from the INTERMAGNET Web site.

Application for membership implies that the Institution will agree to do the following:

1. Abide by the INTERMAGNET Principles and Conditions (Section 1.4)
2. Comply with INTERMAGNET Formats and Technical Standards.
3. Keep its IMOs within specifications and in operation.
4. If using satellite communication, keep its DCPs operating within allotted transmission time 'windows'. Upon receipt of notification from a Geomagnetic Information Node (GIN) that a DCP is transmitting outside of its allotted time window, the responsible Institute agrees to stop the transmission or correct the timing of transmission within 24 hours.
5. Provide definitive data from its IMOs for the annual CD-ROM.
6. Communicate any instrument or practice change to the IMO sub-committee chairman.

IMOs not complying with these conditions or not submitting data for two years risk removal of IMO status.

INTERMAGNET will:

1. Provide on-line access to data from all IMOs for up to 1 year.
2. Provide definitive data from IMOs on a CD-ROM within approximately 6 months of the end of each year.

More information on the application form can be obtained from the IMO sub-committee chairman:

Christopher W. Turbitt
British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
UK
TEL: 44-131-667-1000
FAX: 44-131-667-1877
INTERNET: c.turbitt@bgs.ac.uk

DOCUMENTS AVAILABLE

INTERMAGNET Technical Reference Manual.
INTERMAGNET Membership Application.
Suppliers of Observatory and Data Transmission Equipment.

APPENDIX G-1 (Cont'd)

INTERMAGNET MEMBERSHIP APPLICATION FORM (V-2.6 September 2012)

Date submitted:______________________________

OBSERVATORY

Name: ____ IAGA code: ____________
Latitude: ______________________________ Longitude: ______________________________
Elevation: ______________________________
Street Address: ____
City: ______________________________ Prov/State: ______________________________
Country: ______________________________ Code/Zip: ______________________________
Phone: ______________________________ (with country code)
Fax: ______________________________
E-mail: ____

OBSERVATORY CONTACT

Name: ____
Street Address: ____
City: ______________________________ Prov/State: ______________________________
Country: ______________________________ Code/Zip: ______________________________
Phone: ______________________________ (with country code)
Fax: ______________________________
E-mail: ____

INSTITUTION

Name: ____
Contact name: ____
Street Address: ____
City: ______________________________ Prov/State: ______________________________
Country: ______________________________ Code/Zip: ______________________________
Phone: ______________________________ (with country code)
Fax: ______________________________
E-mail: ____

APPENDIX G-1 (Cont'd)

INTERMAGNET INSTRUMENT SPECIFICATION FORM (V-2.6 September 2012)

Values shown in square brackets [ ] are target values.

A. CONTINUOUSLY RECORDING VECTOR MAGNETOMETER

Instrument Type: ______________________________

Manufacturer: ______________________________

Components Measured XYZ ( ) HDZ ( ) DIF ( ) Other:__________

Sensor tilt correcting suspension: Yes ( ) No ( )

Resolution of digital data [0.1nT]: ____________nT

Automatic dynamic range of digital data: ____________nT

Sampling rate of digital data: ____________Sec.

Digital filtering conforms to INTERMAGNET specification: Yes ( ) No ( )

If not in conformance, please gives details of the filtering algorithm used: ______________________________

____

____

____

____

____

Sensor thermal coefficient [0.25nT/°C]: ____________nT/°C

Electronics thermal coefficient [0.25nT/C°]: ____________nT/°C

Temperature variation range expected for sensor: ____________°C

Temperature variation range expected for electronics:____________°C

B. CONTINUOUSLY RECORDING SCALAR MAGNETOMETER

Instrument Type: ______________________________

Manufacturer: ______________________________

Resolution of digital data: ____________nT

Automatic dynamic range of digital data: ____________nT

Sampling rate of digital data: ____________Sec.

C. DATA ACQUISITION SYSTEM

Time synchronization: Yes ( ) No ( )

Maximum time error if not synchronized: ____________Sec./Month

Recorded data files: [check all that apply]		Recorded	Filtered Yes	Filtered No
	1min	( )	( )	( )
	5sec	( )	( )	( )
	1sec	( )	( )	( )
	Other_____	( )	( )	( )

Data storage capacity: _____________Weeks

Uninterruptible power supply: Yes ( ) No ( )

If yes: _____________Hours

D. DATA TRANSMISSION

An IMO must communicate its data to a GIN within 72 hours either by Satellite or E-mail. Three months of data transmission are required before the INTERMAGNET membership application is considered.

1. Satellite Transmission

Satellite: GOES W ( ) GOES E ( ) METEOSAT ( ) GMS ( ) Other:___________

Transmitter Type: ___________________________

DCP address: ___________________________

DCP channel: ___________________________

Response time: _____________________Hours

(This is the time it would take to shut off your transmitter if INTERMAGNET determines that your DCP timing has drifted into another satellite transmission slot)

2. E-mail communication

Sent to GIN: Edinburgh ( ) Golden ( ) Kyoto ( ) Ottawa ( ) Paris ( )

Frequency of transmission: Daily ( ) 2 days ( ) 3 days ( ) Other:___________

Observatory or data relay E-mail:____

E. OBSERVATORY BASELINE INFORMATION

Along with this application form (using the Data Quality Control section of the Technical Reference Manual as a reference), please submit a sample of the observatory baselines for a minimum 1 year interval. Preferably, these data should be presented in graphical form using the Excel spreadsheet available on the INTERMAGNET Web site which produces baseline graphs of observed and adopted baseline values in a standard format. Please give details on the baseline adoption procedure and explain offsets if there are any. Also, please submit the one-minute raw data using standard INTERMAGNET formats for the same period including the total field value recorded by a total field magnetometer if available.

Expected baseline variation [5nT/year]: _________________nT/year

APPENDIX G-1 (Cont'd)

F. ABSOLUTE INSTRUMENTS

Measurement frequency: ______________________________

1. Declination (D)

Instrument Type: ____

Manufacturer: ____

Measurement accuracy: ______________________________

2. Inclination (I)

Instrument Type: ____

Manufacturer: ____

Measurement accuracy: ______________________________

3. Total field (F)

Instrument Type: ____

Manufacturer: ____

Measurement accuracy: ______________________________

4. Horizontal component (H)

Instrument Type: ____

Manufacturer: ____

Measurement accuracy: ______________________________

5. Vertical component (Z)

Instrument Type: ____

Manufacturer: ____

Measurement accuracy: ______________________________

Acknowledgments

We gratefully acknowledge the many and significant contributions to the Executive Council and Operations Committee provided by past members.

EXCON

William F. Stuart UK
Arthur W. Green Jr. USA
Richard L. Coles Canada
Jean-Louis LeMouël France
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